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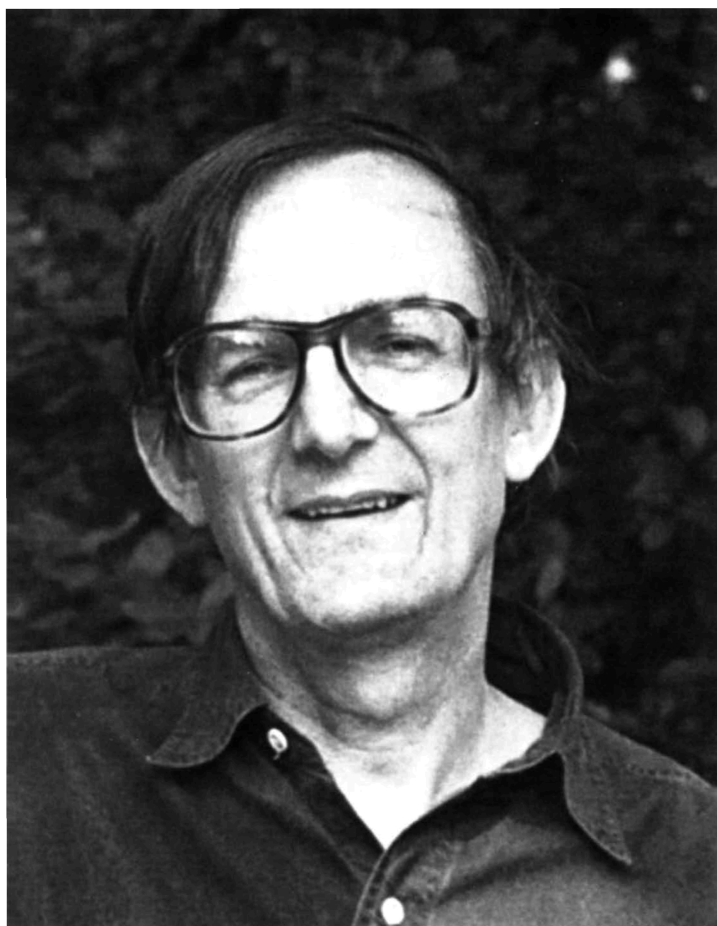
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John D. North

BETWEEN DEMONSTRATION AND IMAGINATION

Essays in the History of Science and Philosophy

Presented to John D. North

EDITED BY

LODI NAUTA AND ARJO VANDERJAGT



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DUE NORTH

John North belongs to a class of scholars of which he seems to be the only member. While most of us are glad to become a specialist in one or two areas and concentrate on one particular historical period throughout our careers, North's published works cover the entire history of science from the long barrows of the Neolithic period to the black holes in modern cosmology. He employs mathematical astronomy with the same ease with which he reads medieval astronomical tables, calendars and almanacs, and he knows the principles of astrolabes as intimately as those of the modern computer. Whatever subject comes under discussion, he brings to it a historical sensitivity which avoids the Scylla of an analytical approach without history and the Charybdis of an exegetical approach without analysis. These essays, written by some of his colleagues for the occasion of his sixty-fifth birthday, can therefore mirror only a few of his interests.

John David North was born in Cheltenham in 1934. From an early age he was interested in mathematics, trying to refute Euler's formula on polyhedra at the age of 16. He studied mathematics at Merton College in Oxford, but soon his interests took him further afield to philosophy. He attended the lectures of Gilbert Ryle, the seminars of J. L. Austin and H. P. Grice, and those on logic by P. Strawson and W. Kneale. Philosophers with a scientific background were few in Oxford, and North was lucky to have John Lucas as one of his tutors. Even more important was his meeting with Alistair Crombie, who had shortly arrived in Oxford to teach the history of science. Crombie's seminars greatly stimulated North's awakening interest in an historical approach towards philosophical and scientific subjects, an approach conspicuously absent in analytical philosophy. As North later said, these seminars were truly memorable occasions, bringing him into contact with scholars such as Gerd Buchdahl, James Weisheipl, Alexander Koyré, G. J. Whitrow, H. R. Harré and many others, but above all with Crombie himself, with whom he became a life-long friend until the latter's death in 1996.

North's thesis, published as *The Measure of the Universe. A History of Modern Cosmology*, already showed the features that have been his hallmark ever since: thoroughness, completeness of exposition, an enviably easy mastery of the required mathematics, a lucid style and a strong sense of the historical dimension in which scientific achievements must be viewed. The book was praised as 'a virtually complete history of modern mathematical cosmological theories', and its reprint as a Dover paperback in 1990 indica-

tes that it has not been surpassed in breadth, scope and attention to technical detail.

North's intellectual universe had never been a steady-state, but from then on it was rapidly expanding, or perhaps we should say, contracting, for his interests took him ever further back in time. In the mid 1960s he was asked to explain the workings of a scientific instrument sent by The Museum Boerhave in Leiden. This was the beginning of a fascination with medieval astronomy and astrology, astrolabes, clocks, calendars, tables, almanacs, and so forth. Fortunately, he did not pay attention to Lorenzo Minio-Paluello's advice not to be seduced by the blandishments of the past: 'Look, North, what it has done to me!' North soon mastered the principles of the instrument and was able to explain all its features. His studies of medieval (and in particular fourteenth-century) astronomy and astrology culminated in his monumental work in three volumes on Richard of Wallingford (1976), the fourteenth-century abbot of St Albans who was also an important astronomer and mathematician. North edited, translated and commented on all of Richard's extant works. The most important text is the oldest surviving description of any mechanical clock, which North had found in the Bodleian Library. The *Treatise on the Albion* receives a masterful commentary, as does the *Quadripartitum*, the first comprehensive treatise on spherical trigonometry in Western Europe. Everything is explained: clocks and the importance of mechanical escapements, astronomical tables, calendars, spherical trigonometry, astrological meteorology and much more. The world of Richard of Wallingford, in which the craft tradition was united with the academic, was an unfamiliar one to most historians of science, who were more interested in the achievements of the Mertonian Calculators, including Thomas Bradwardine, William Heytesbury, John Dumbleton, and Richard Swineshead. These scholars were discussed in other publications by North, notably in his two long chapters written for the *History of the University of Oxford*, published in 1992, almost 20 years after their composition.

Much of this work on fourteenth-century science was done during his years as curator of scientific instruments at the Old Ashmolean Museum (1968-77), where as a student he had attended Crombie's seminars. He was a visiting scholar in Frankfurt (1967) and Aarhus (1974), and became close friends with Willy Hartner and Olaf Pedersen. He came back to Oxford not so much with a changed perspective on the subject but with an ever-increasing knowledge of it and of the people who studied it. He was therefore in a perfect position to take up the job of general editor of the *Archives internationales d'histoire des sciences*, which he ran for almost 10 years with great efficiency and tact.

The fourteenth century remained at the centre of North's attention. In the late sixties he had published a series of articles on Chaucer in which he

showed that some of Chaucer's poetry is structured around the calendar and the planetary almanac. Obviously, this has implications for the dating of Chaucer's works. He continued to work on Chaucer and found out that his earlier picture had been far too cautious. In *Chaucer's Universe* (1988), praised by Alastair Fowler as one of 'the century's monuments of scholarship' (*Times Literary Supplement*, 2 Dec. 1988), North showed that Chaucer had recourse to a great variety of astronomical techniques and employed astrological lore for structuring his plots (which had their literary sources, of course) and dressing up his tales. Some of Chaucer's pilgrims and other characters are modelled on the stars (for example, Chauntecleer's hens on the Pleiades), some of the plots are imitations of cosmic events (*The Knight's Tale*, for example, is full of correspondences between planets, gods and human subjects), while other works, such as *The Parliament of Fowls*, have several independent forms of chronological reference. To say all this is to risk, as North himself writes in the preface, 'of being bracketed with those who try to prove that Bacon wrote Shakespeare, or that the history of the world is implicit in the music of Bach' (p. x). And this is only mildly put, as he now knows: In a recent controversy about an astrological interpretation of Holbein's painting *The Ambassadors*, he is bracketed with those who claim that 'Elvis is alive', that a painting of Poussin gives indications where to find the Holy Grail and that computer analysis of the *Mona Lisa* shows it to be a self-portrait of Leonardi da Vinci in old age. He is reconciled with this fate, and has grown used to letters from astrologers who apparently skipped the preface to his monograph *Horoscopes and History* (1986), in which he states with Nabokovian irony: 'Heaven forbid that the book should be judged as a manual for astrologers—even though it may be safely expected to become compulsory reading for all their introductory courses'.

By the time *Chaucer's Universe* was written, North was already fully integrated in the social and intellectual life of Groningen, where he had accepted the chair in the history of science and philosophy in 1977 (the Dutch formulation may be omitted here for reasons of space). Historians of science would not have mentioned Groningen as one of the centres of their interests, but North found a lively and prospering university, which he has come to like greatly, finding his second home, after Oxford, in Paterswolde.

Paterswolde brought him also something else. When plans of excavations made on the site of a Bronze Age burial mound at Harenermolen, close to Paterswolde, were shown to him, North noticed a symmetry which he found intriguing and which led him to pursue an old interest in archaeo-astronomy. This fascination resulted eventually in another major work of scholarship, *Stonehenge. Neolithic Man and the Cosmos* (1996). Before he comes to discuss the great monument itself, North gives a thorough survey of long barrows as well as linear and ditched monuments from the later Neolithic

period in northern Europe, suggesting that long barrows were used as artificial horizons for rising and setting stars. Armed with a number of fairly simple mathematical principles and techniques that may have been of influence in the construction of these prehistoric monuments, he argues that Stonehenge, too, embodies significant alignments of the sun and moon. The book presents much new evidence and many new ideas, including one which will, without doubt, be of the greatest importance in future debates on Stonehenge. According to North, the configuration of the stones at Stonehenge blocked lines of sight and made possible the observation of the setting of the midwinter sun rather than its midsummer rising, as has generally been held. Thus, the viewing was undertaken across the monument, not from its centre. The ramifications of North's argument are wide-reaching, for if it is accepted, one will have to allow for more continuity in the development of geometrical principles and their application than has generally been done. Greek geometry in the pre-Socratic period, often described as a miraculous product of the Greek genius, had its forerunners in the principles employed in the construction of a whole range of Neolithic monuments. From one point of view, the argument seems to amount to a mild qualification of Crombie's thesis that science is essentially a European enterprise, which started with the Greeks. Faced with the highly sophisticated algorithms of Mesopotamian and Egyptian science, Crombie answered that

there is nothing in any surviving text corresponding to a theorem or a proof, no theory of numbers or generalized algebra, nothing that might indicate even an inkling of such conceptions. Likewise there is nothing in any of the Mesopotamian or Egyptian writings on astronomy, medicine or other empirical subjects corresponding to a general theory, a generalized explanation, a conception of natural causation (*Styles of Scientific Thinking in the European Tradition*, i, p. 96).

Though such an answer would also be applicable to the achievements of Neolithic man, it is doubtful whether North would accept it in its entirety. His closing remarks in his Stonehenge book (e.g. Appendix 6 on astronomically directed worship in later societies; North has always been generous in supplying appendices) suggest otherwise. As he puts it in a published lecture, held for the *Koninklijke Nederlandse Akademie van Wetenschappen*:

It seems to me clear that some of those principles, developed in connection with astronomically ordered ritual over a whole range of Neolithic monuments, were the forerunners of some fundamental ideas that we judge to have been important in the rise of Greek geometry in the pre-Socratic period. If this is true, then even a thinly spread farming community was able to nourish the beginnings of a scientific culture in the absence of the written word.

The pattern of reactions to the book on Stonehenge was by now a familiar one: the highest praise from historians of science, scepticism from those scholars who are slow to welcome expertise from outside their own discipline, especially when it involves evidence of a mathematical character, which one cannot easily verify for oneself. Some of the criticisms can be dismissed easily enough, for they exhibit only a disturbing ignorance of the mentality of the period, for example that Holbein could never have indulged in such a superstitious activity as astrology, that the father of English literature could not possibly be versed in technical astronomy, or that there were no systematic observations of the heavens before the Greeks. One typical reaction that North has frequently encountered is that, since 'it was' does not follow from 'it could have been', his arguments cannot really be valid. Alternatively, since there seems to be no limit to the possibilities of linking heavenly events to human artefacts—'if you point anything at the sky then it would hit a star or phase of the sun or moon sooner or later', as one critic puts it—, no choice among the alternatives can be made. Lest one is tempted to choose or even adapt the data to one's preconceived notions, one should preferably omit any such reference to the heavens. What cannot be tested is trivial at best, or cannot be true at worst.

North has no difficulty to show the fallacious nature of many such arguments. It is the overall plausibility of the argument that counts, not the fact of whether a subsidiary hypothesis can be proved formally or not. And one can assess the plausibility of an argument only when one is able to formulate the boundary conditions in which something might have been the case. In the case of Chaucer this means that 'it is not enough to have a knowledge of mathematical astronomy or astrology; one must also be aware of the way a fourteenth-century writer looked at the universe of planets and people, of stars and souls, of macrocosm and microcosm' (*Chaucer's Universe*, p. viii). In the case of prehistoric monuments, one must know, inter alia, which procedures and techniques of observations were either probable or possible or at least could have been known, within what time limits the monument was erected, which stars could be seen and at what time, and so on. Of course, the inference from 'it could have been' to 'it was' involves a lot of hard work, and formal proofs are not to be expected, but neither are his arguments the product of an unchecked flight of an overenthusiastic imagination. Far from it. North supports his arguments in various ways, finding independent evidence for his base hypotheses, and linking ancient customs and rituals with later ones in as many short steps as possible (the historical continuity in the alignment of buildings on celestial events is an example). In the course of these debates North has many valuable remarks to make on the logic of presentation of evidence and on the methodology of interpretation. To him attention to the argumentative side, both in history

and in modern historical scholarship, belongs to the heart of the subject, as is indicated by the titles of articles such as 'Science and Analogy', 'Structure and Explanation in the History of Ideas' (his inaugural lecture), 'Aspects of the Language of Medieval Mathematics' and many more. As a historian of a 'wretched subject', as he has called astrology with a phrase from Neugebauer, North is aware more than anyone else that (as he writes) 'not all nonsense is equally foolish':

anyone who is so interested *must* take into account that no-man's-land between truth and falsehood, i.e. those arguments that were *reasonably* based in the light of the knowledge of the time, but in our own time are judged to have been mistaken. The past, after all, like the present, framed irrational as well as rational truths, rational as well as irrational falsehoods ('Science and Analogy', repr. in *The Universal Frame*, p. 285).

The point is well-made, but the meaning might easily be missed. This is no social history of science, though there is hardly a study by North in which societal influences as well as religious and metaphysical speculations do not play a role. This is no history in the Whiggish style either, though he himself has said—perhaps as an antidote to the rise of the sociological approach in which the historian's job to judge the quality of arguments is viewed with suspicion—that 'While not the most single-minded of Whig historians, I confess willingly to being a fellow-traveller' (preface to *The Universal Frame*). In the last analysis, his view has to do with scientific ideas and theories as well as with the styles of argumentation and explanation in which they are expressed. It leaves far behind facile dichotomies, such as an externalistic versus an internalist historiography of science, the body of scientific knowledge versus the methodology, and contents versus style. North's view of the subject is a cognitive one, trying to catch at the mind of people in the past and to see how they developed their ideas, arguments and theories in order to make sense of the universe around them, and how they put that knowledge into practice.

Because knowledge of the astronomical and astrological arts and techniques, which have informed so many products of the past, has generally been lost to modern man, it requires unusual skills to decode the hidden meanings they contain. This is particularly true of Chaucer, who cleverly effaced the traces of his art, but it is no less true of Dante, Holbein, and so many other people from the past whom North has discussed in his work. (To appreciate the true width of his range of learning one may consult the bibliography of his works which concludes this volume.) In bringing to life these forgotten mentalities, his role is that of the eagle in Chaucer's *House of Fame*: to instruct his audience in the niceties of higher learning:

Now herkene wel, for-why I wille
 Tellen the a propre skille,
 And a worthy demonstracion
 In myn ymaginacion

(*House of Fame* 725-8)

All the ingredients with which the eagle wakes the poet's attention—skill, demonstration and imagination—are present in North's intellectual flight, and it has brought him fame. History, he has written, is made of reputations, not of merit (*The Fontana History of Astronomy and Cosmology*, p. 253), but his place in the historiography of science is well-secured and based on merit. There is no point in listing all the memberships of learned societies and the honours he received, but mention must be made of the Médaille Alexandre Koyré for his book on Chaucer and a D.Litt degree from Oxford for his entire œuvre.

The Dutch academic world, the University of Groningen, and its Faculty of Philosophy in particular, which he has served loyally for 22 years, are deeply grateful to him. It did not require expertise in reading astronomical tables to calculate the year and month of his retirement, and to predict that Marion and he will move into their house at Oxford again, nearer to their expanding family. The day of his valedictory lecture is not marked by a great planetary conjunction, but for his many friends in the Netherlands it will mark the beginning of a sad disjunction. It is a relief, however, to think that a journey from Groningen to Oxford does not take as long as the arrival of the next great conjunction. We wish them both a happy and long semi-retirement.

The editors of this volume would like to thank the authors for their contributions and for carefully correcting their proofs. All of us have done our best to avoid the situation in which North would have had to echo the words of the great historian Theodor Mommsen, who said, when presented with a Festschrift: 'Monate werde ich da brauchen, um den Unsinn zu widerlegen'. From what has been said above, it must be clear that we have not tried to cover all the subjects which North has studied, but rather that we focused on a range of topics which has always stood at the centre of his attention: astronomy, cosmology, astrology and philosophy in the Middle Ages and the early modern period.

We thank the University Library and the Faculty of Philosophy of the University of Groningen for providing facilities and the latter also for financial support. A small grant from the Groninger Universiteitsfonds towards the publication of this volume is also gratefully acknowledged. Above all, the editors are grateful to Monique Smit and Nanda Weiland for their dedicated work on a demanding and very complicated manuscript, which continued to hide a great many codes of a nature that would have

taxed even such a master in code-breaking as John North. Thanks to their indispensable help, the book can now be published on time. Finally, we thank Koninklijke Brill of Leiden for publishing this volume in their series Brill's Studies in Intellectual History.

Lodi Nauta

CONTRIBUTORS

Charles Burnett

The Warburg Institute, Woburn Square, London WC1H 0AB, England
email: ch-burne@sas.ac.uk

Bruce S. Eastwood

Dept. of History, 1715 Patterson Office Tower, University of Kentucky,
Lexington Kentucky 40506-0027, USA
email: bseast01@ukcc.uky.edu

Owen Gingerich

Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge,
Mass. 02138, USA
email: ginger@cfa.harvard.edu

Bernard R. Goldstein

Dept. of Religious Studies, University of Pittsburgh, Pittsburgh PA 15260, USA

Edward Grant

Dept. of the History and Philosophy of Science, Goodbody Hall 130,
Bloomington, Indiana 47401, USA
email: grant@indiana.edu

Keith Hutchison

Dept. of History and Philosophy of Science, The University of Melbourne,
Parkville 3052, Australia
email: k.hutchison@hps.unimelb.edu.au

David A. King

Institut für Geschichte der Naturwissenschaften, FB 13, Goethe University,
60054 Frankfurt/M., Germany

Richard Lorch

Institut für Geschichte der Naturwissenschaften, 80306 Munich, Germany

F. R. Maddison

New House, Old Boars Hill, Oxford

Lodi Nauta

Faculteit der Wijsbegeerte, University of Groningen, A-weg 30, 9718 CW
Groningen, The Netherlands
email: lodi@philos.rug.nl or: l.w.nauta@ub.rug.nl

Detlev Pätzold

Faculteit der Wijsbegeerte, University of Groningen, A-weg 30, 9718 CW
Groningen, The Netherlands
email: d.h.k.patzold@philos.rug.nl

J. A. van Ruler

Hoger Instituut voor Wijsbegeerte, Kardinaal Mercierplein 2, 3000 Leuven,
Belgium
email: jl.vlasblom@wxs.nl

Julio Samsó

Departamento de Arabe, Universidad de Barcelona, Gran Vía 585, 08071
Barcelona, Spain
email: comes@fil.ub.es

Keith Snedegar

Political Science and History, Utah Valley State College,
Orem, UT 84058-5999, USA
email: snedegke@uvsc.edu

A. J. Turner

24 Rue du Buisson Richard, 78600 Le Mesnil-le-Roi, France

Arjo Vanderjagt

Faculteit der Wijsbegeerte, University of Groningen, A-weg 30, 9718 CW
Groningen, The Netherlands
email: a.j.vanderjagt@philos.rug.nl

G. Frederici Vescovini

Università degli studi di Firenze, Dipartimento di scienze dell' educazione,
Palazzo Corsini, Via di Parione 11/B, 50123 Florence, Italy

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SECTION ONE

ASTROLABES, HOROSCOPES, AND THE DIVISION OF TIME

DAVID A. KING

BRINGING ASTRONOMICAL INSTRUMENTS BACK TO EARTH—
THE GEOGRAPHICAL DATA
ON MEDIEVAL ASTROLABES (TO CA. 1100)*

‘This is the side for latitude 66;25°, which is the end of the seventh climate [sic] and the northern limit of the inhabited part of the earth. What lies beyond is desolate and unknown. I have engraved these markings in order to ponder the power of Almighty God and (no less) because of the need of the person viewing (these markings) of a modest knowledge of astronomy, so I engraved the 24 equal hours (which is the maximum length of daylight at that latitude).’ (Inscription on one of the plates of an unsigned astrolabe made in Cordova in the year 1054/55 (#3622).)

‘Like the modern electronic computer, the astrolabe in the Middle Ages was a source of astonishment and amusement, of annoyance and incomprehension. Imprecise as the astrolabe may have been in practice, it was undoubtedly useful, above all in judging the time. The instrument might have been used, more often than not, in the dark, but “dark” is hardly the word to describe the age in which it was so widely known and so well understood.’ (John North, ‘The Astrolabe’, p. 220 of the reprint.)

The astronomical instruments of the Islamic and Christian Middle Ages constitute a veritable gold-mine of historical information that until recently had barely been tapped.¹ Thus, for example, we find new mathematical solu-

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¹ For a new introduction to the sources see King, ‘Astronomical Instruments between East and West’ (Islamic and European), and idem, ‘Strumentazione’ (Islamic). The main research tools of the past are Gunther, *Early Science in Oxford*, II, and idem, *Astrolabes of the World* (deals with Islamic and European astrolabes, long outdated); Mayer, *Islamic Astrolabists* (still

tions to astronomical problems rendered graphically,² artistic developments related to astronomical and/or cultural or religious criteria,³ linguistic clues to provenance and later fate,⁴ problems relating to positions of stars on astrolabe retes,⁵ and unusual number-notations used to mark scales.⁶ In particular, a wealth of information can be gained from the geographical data explicitly or implicitly to be found on these instruments, and the purpose of this paper is to survey the data from the earliest such instruments—for convenience choosing a closing date of ca. 1100⁷—and offer some interpretations of them. For the latter task we are fortunate to have the data-base

the best source on Muslim instrument-makers—see below); and Price et al., *Checklist* (computer-sorted data-base with one line of information on each known astrolabe). There are also several museum catalogues of widely-varying quality and scope. For the future we have—in *sha' Allah*—Brieux and Maddison, *Répertoire*, listing Muslim makers alphabetically with brief descriptions of their instruments (long promised but still not published), and a catalogue currently being prepared in Frankfurt containing detailed descriptions of all Islamic and European instruments to ca. 1550, arranged chronologically by region (announced with much enthusiasm but still a long way from being publishable—see King, 'Medieval Astronomical Instruments: A Catalogue in Preparation'; idem, '1992—A Good Year for Medieval Astronomical Instruments'; idem, 'Der Frankfurter Katalog mittelalterlicher astronomischer Instrumente'.

² A preliminary discussion is in North, 'Graphical Representation of Functions'. More examples were presented by F. Charette in his contribution 'Numbers and Curves: the Graphical Representation of Functions in Islamic Astronomy' to the XXth International Congress of the History of Science, Liège, July, 1997. What is perhaps the most spectacular example from a mathematical point of view (if not from a graphical point of view—it is simply a circle cunningly situated) is described in Puig, 'al-Zarqalluh's Graphical Method'.

³ Two examples on the retes of astrolabes are the quatrefoil and the bird's head for Vega, which both seem to be Byzantine in origin. See King, 'Astronomical Instruments between East and West', 170, and King and Maier, 'Catalan Astrolabe', 680-683 (*ad* #162).

⁴ See Maier, 'Bemerkungen zu romanischen Monatsnamen auf mittelalterlichen Astrolabien'; idem, 'Zeugen des Mehrsprachigkeit: mittelalterliche romanische Monatsnamen auf islamischen astronomischen Instrumenten'; idem, 'Astrolab aus Córdoba'; and King and Maier, 'Catalan Astrolabe'. In these studies, vernacular forms of the Latin and Romance month-names, vernacular forms of Latin star-names, and basically any available linguistic straw that can be grasped are used to pinpoint the provenance of instruments, or—in the case of medieval Latin additions to Islamic instruments—the location of their mutation.

⁵ See Stautz, 'Früheste Formgebung der Astrolabien', and idem, *Mathematisch-astronomische Darstellungen auf Instrumenten*. A particularly interesting instrument (#4523), on which ecliptic and equatorial coordinates have been confused, is discussed in idem, 'Astrolab aus dem Jahr 1420'.

⁶ See Destombes, 'Astrolabe Carolingien', 2-4, and King, 'Earliest European Astrolabe', 371-372, on the alphanumerical notation found on a 10th-century astrolabe from Catalonia (#3042). The monastic number-notation found on one 14th-century Northern French astrolabe (#202) is also attested in some two dozen medieval manuscripts and was known to a series of Renaissance authors: see King, 'Rewriting History through Instruments: The Secrets of a Medieval Astrolabe from Picardy'; idem, 'A Forgotten Number-Notation of the Cistercians'.

⁷ This limit has the advantage that amongst European instruments I need consider only the 10th-century Catalan astrolabe (#3042), with sporadic references to others with plates for the climates. I hope some day to prepare studies similar to this one dealing with Islamic instruments after ca. 1100, and European instruments after ca. 1300. An investigation of the star-names and the selection of stars on astrolabe retes would also be worthwhile.

of coordinates from some 70-odd medieval Islamic geographical tables published by Ted and Mary Helen Kennedy.⁸ These data are presented in Appendix 1, and the instruments from which they are extracted (listed in Appendixes 4 and 5), which happen to all be astrolabes,⁹ belong to the following categories:

1. *Byzantine*: A single complete astrolabe dated 1062, and a plate from another.
2. *Early Eastern Islamic*: astrolabes from ca. 750 to ca. 1100, mainly Baghdad (14 pieces), then Isfahan (3 pieces).
3. *Early Western Islamic*: astrolabes from ca. 900 to ca. 1100, mainly Andalusia (18 pieces).
4. *Earliest European*: A single astrolabe from tenth-century Catalonia representing a hypothetical Roman tradition and also displaying some Islamic influence; and various selected astrolabes from before ca. 1300.

It is the plates of the astrolabes, serving different latitudes, which provide the kind of information we are looking for, together with occasional horary quadrants for specific latitudes on the backs of the astrolabes.¹⁰ With one notable exception (see below), there are no gazetteers on these early instruments giving the coordinates of a series of localities, such as we find on later Islamic astrolabes.¹¹ But we are witness to a deliberate and successful effort to make the instruments universal,¹² that is, useful in 'the whole world'.

⁸ Listed as Kennedy and Kennedy, *Coordinates* (see also n. 51 below). A grand total of 12,000 entries comprising source, place-names, longitudes and latitudes is presented according to the four different arrangements. The corpus is currently being updated by M. Comes in Barcelona. A similar undertaking for medieval European coordinates would be worthwhile. Various published tables are repr. in *Islamic Geography*, vol. 23 (1992): *European Geographical Tables Based on the Arabic Tradition*. It is of considerable interest to compare the data in two 15th-century European lists, one English, the other Italian, published together in North, *Horoscopes and History*, 186-195.

⁹ The best introduction to the astrolabe is still North, 'The Astrolabe'. However, as I took pleasure in telling John some years ago, his illustration of an exploded astrolabe with two plates is inaccurate—there should be three plates, which, together with the mater, provide seven surfaces for the climates. On the medieval Islamic reports and fantasies about the inventor of the astrolabe and its introduction in the Islamic world see King, 'Origin of the Astrolabe'.

¹⁰ These were invented in Baghdad in the early 9th century: see King, 'al-Khwarizmi', 30-31, and also n. 28 below.

¹¹ The gazetteer on #3 is a later addition. For a much later example see Morley, 'Astrolabe of Shah Husayn', 22-26. This and numerous other gazetteers are investigated in King, *Mecca-Centred World-Maps*, Section 3.5.

¹² There was serious interest in universal solutions to problems of spherical astronomy and mathematical geography in the Islamic Middle Ages, whose origins are to be detected already in Greek science: see King, 'Universal Solutions in Islamic Astronomy'; idem, 'Universal

Most of the early Islamic astrolabes are signed; on the other hand, medieval European astrolabes before ca. 1400 are mainly unsigned. For the Islamic pieces these signatures, often geographically bound,¹³ together with distinctive regional rete-design patterns and the geographical information derived from the plates, provide a reasonably secure geographical location for their fabrication. For the European astrolabes, with no signatures and without our having much control over regional trends in design, ascertaining the provenance has until recently often been a matter of guesswork, some of it with incorrect results.¹⁴ Thus in this study of mainly Islamic materials it is the inherent interest of the data on the plates that is our concern, rather than the use of these data to establish the provenance of the instruments.

1. *The seven climates*

The earliest astrolabes bearing inscriptions in Greek (second?-eighth? centuries)—alas not one is extant—were provided with seven sets of markings for the seven climates of Antiquity, so as to render them universal.¹⁵ The middles of the climates (hereafter C1-C7) are defined by the lengths of maximum daylight in hours, thus:

C1	C2	C3	C4	C5	C6	C7
13	13 ½	14	14 ½	15	15 ½	16

spectacular new 'universal solutions' are presented in Charette, 'Najm al-Din's Monumental Table', and King, *Mecca-Centred World-Maps*.

¹³ Thus, for example, the three makers named al-Isfahani (#3 and #122, the former made by two brothers) seem indeed to have worked in Isfahan. However, as we shall see, al-Khujandi made his astrolabe (#111) neither in or for Khujand whence his family hailed nor in or for Rayy where he is known to have worked, but rather (perhaps in or at least) for Baghdad. On this kind of problem see also King and Turner, 'Bessarion's Astrolabe', 181-182 and 197-198, on #640, which bears an inscription implying that it came into being in Rome, whereas it was probably made in Vienna.

¹⁴ This is not to belittle Gunther's monumental achievement. But we may note, for example, that his no. 163 listed as Spanish is French, and his no. 173 listed as Italian is German. His no. 169 was listed as Sicilian because he calculated the latitude of the only astronomical markings as 39°, whereas, in fact, it is 24°: this piece is nevertheless not Syenian but indeed Italian, although not necessarily Sicilian. In fact it is a copy of a special universal astrolabe with plates for each of the climates (see next note) in which the maker contented himself with markings for just one climate, namely, the second. There are many pieces for which Gunther offers no provenance but on which there is implicit geographical data.

¹⁵ See, for example, Gunther, *Astrolabes of the World*, 65 and 83, for the relevant passages in the treatises of Philoponus (ca. 530) and Severus Sebokht (before 660). On the climates in Antiquity the standard source is Honigsmann, *Die sieben Klimata*; see also Neugebauer, *HAMA*, II, 725-733. The climates in the Islamic sources are treated in the article 'Iklim' by A. Miquel in EI², but the most useful study is Dallal, 'Al-Biruni on Climates'.

and the beginnings and ends of the climates are appropriately defined by $\frac{1}{4}$ hour less or more than the lengths at the middle.

Quite by chance certain localities of significance in the history of ancient and/or medieval astronomy lie close to the midpoints of the climates, namely: the Yemen (C1); Syene (modern Aswan) (C2); Alexandria / Cairo (C3); Rhodes / Aleppo / Rayy (near modern Tehran) (C4); Constantinople / Catalonia (C5); the Po Valley (C6); and Paris / Vienna / Nuremberg (C7). This fortunate situation partly accounted for the popularity of the climates amongst medieval instrument-makers, Muslim and Christian alike. Indeed, the climates are of paramount importance for understanding the geography of medieval Islamic and European astrolabes and other instruments, and they have not received the attention they deserve in modern writings either on medieval geography or medieval instrumentation.¹⁶

Since the climates are defined in terms of the length of longest daylight, they are dependent on the value assumed for the obliquity of the ecliptic, which changes over the centuries. Ptolemy's value was $23;51,20^\circ$ and the latitudes he gives for the climates are based on it. Muslim astronomers commissioned by the Caliph al-Ma'mun in the early ninth century measured the obliquity anew and came up with values of $23;33^\circ$ and $23;35^\circ$;¹⁷ the latitudes of the climates would of necessity be different—see Appendix 3—although the Ptolemaic tradition was not abandoned forthwith, for most Muslim astrolabists in our period used Ptolemy's value.¹⁸ The latitudes of the climates rounded to the nearest degree are:

16° — 24° — 30° — 36° — 41° — 45° — 48° .

We find the climates represented explicitly or almost so on the very earliest surviving Eastern Islamic astrolabes (#3702—eighth century?) and the very earliest known Western Islamic astrolabe (#4042—tenth century?), as well as some of the earliest European astrolabes (#161, #166, #167, #589, etc.).¹⁹

¹⁶ The explicit and implicit use of the climates on Islamic and European instruments well into the Renaissance is noted in King, 'Astronomical Instruments between East and West', esp. 152 and 168-169, and also *Focus Behaim Globus*, I, 107 and 111. There is a lot more on this subject that needs to be said.

¹⁷ For values used by Muslim astronomers see the EI² article 'Mintakat al-burudj' [= zodiac] originally by W. Hartner, updated by Kunitzsch, esp. VII, 86. Determinations of the obliquity were of course related to determinations of the local latitude.

¹⁸ The sources, presumably originally textual, for the lengths of daylight corresponding to specific latitudes on Islamic astrolabe plates have not been identified. See, however, King, *Mecca-Centred World-Maps*, Section 2.6.2, on a 13th-century table displaying the maximum length of daylight for the latitudes of some 50-odd localities, found in a Persian treatise on the use of the astrolabe.

¹⁹ Some people could not resist modifying these into a more pleasing arithmetical array, namely: 15° — 23° — 30° — 36° — 41° — 45° — 48° (see #161). And others put C1 at 12° ,

Even on later ones (such as #202) they are often there implicitly.²⁰

2. *Traces of the climates*

On the other hand, the only surviving Byzantine astrolabe (#2), dated 1062, no longer bears markings for the seven climates, but rather for Rhodes at latitude 36° associated with C4, and for Hellespont and Byzantium at latitudes 40° and 41° both associated with C5. A carelessly-engraved solitary medieval plate with Greek letters for the altitude arguments (#4509) serves latitude 43°. On a Greek astronomical ring-dial dating from the period 250-350 A.D. excavated at Philippi in 1965, the latitudes served are 31° for Alexandria, 36° for Rhodes, 41 1/3° for Rome, and 45° for Vienne in the Rhone Valley.²¹

The notion of replacing the climates by specific latitudes is thus already an innovation of late Antiquity; certainly it influenced early Eastern Islamic instrumentation. For although, as we have noted, some early instruments in each of the four main traditions of interest here—early Greek, early Eastern Islamic, early Western Islamic, and early European—the seven climates were featured, the innovation of featuring individual latitudes and/or individual localities soon came to predominate on early Islamic instruments and we find it again on numerous other early European astrolabes (for example, #300 with 24°-60° and #558 with 16°-52°), doubtless as the result of Islamic influence augmented by European needs. And in at least the Islamic tradition, both Eastern and Western, the associated maximum length of daylight is usually stated alongside the latitude, serving as a reminder of the origin of the association. In one case (#117), the minimum values are also given. Occasionally the values of daylight do not correspond correctly to the latitudes—see #99, #117 and #122.²² This is particular unfortunate on a single plate (#109), where C6 is incorrectly associated with 41°, although the markings are actually for 45°.

corresponding to the beginning rather than the middle of that climate (see #166).

²⁰ This has plates for latitudes: 24°, 30°, 36°, 41°, 45°, 48°, and because it was made in Picardy, also 50° and 51°.

²¹ On this splendid piece see the preliminary discussion in Gounaris, 'Anneau astronomique antique'.

²² #99 has a plate for 39° associated with daylight 15 hours, whereas the correct value would be 14;48. #117 has the wrong value for 35;30°. #122 has a plate for 31° with daylight 13;58, which is correct for 30°. Note that on the plates for 30° and 42° on #101 the minutes of daylight have been suppressed (see also #99). In general the values are accurately computed, and there are two instances where daylight is given to seconds, perhaps suggesting that all values were originally calculated to this degree of precision: see the values for 21;40° on #118 and for 35;30° on #123, both of which reveal that it was wise not to give all values to seconds.

On two Western Islamic astrolabes, mixed information on localities and climates is presented: on #2572 we have Almería at latitude $36;0^\circ$ associated with C4, and on #3622 we find Hadramawt at latitude $12;25^\circ$ associated with the beginning of C1 (daylight $12\frac{3}{4}$ hours). In both cases no other localities are linked with climates in this way.

3. *Universality achieved by a series of latitudes*

The majority of surviving early Eastern Islamic astrolabes feature a selection of latitudes for specific localities rather than the middles of the climates. Some of these are clearly associable with the climates, others with their boundaries, and yet others with cities (usually not specifically mentioned) that were of importance: 33° for Baghdad, 34° for Samarra, 32° for Isfahan, 24° for Medina, 21° for Mecca, *etc.* It should be noted that Mecca and Medina are not always featured, so that we are not dealing with ‘essential travel-kit for pilgrims’. Jerusalem, although commonly represented in Islamic geographical tables, is not found on any early Eastern Islamic astrolabes, but is found on three Western Islamic astrolabes (#3622, #117, #1139) and on some of the earliest European astrolabes (such as #162, from Catalonia ca. 1300, and #4560, from fourteenth-century Spain). Sometimes the selection was for each degree within certain limits, as is the case with #1026 (33° – 36°). When an instrument made in Isfahan in the tenth century (#3), with markings for 30° , 31° , 32° , 34° , 36° and also 42° , fails to have a plate for 33° (Baghdad), we should bear in mind what the Shiite Buwayhids thought of the Sunnite Abbasids, namely, not much. Only one early Islamic astrolabe (#99) associates localities with specific latitudes, namely, Mecca at 21° and Harran at 36° , and Fustat (Old Cairo) at the distinctive value $29;55^\circ$, apparently supposed to be the latitude of C3 (since daylight is rounded to 15 hours).²³ It is particularly appropriate that Harran be featured, since it was

²³ This value occurs in a set of tables attributed to al-Khwarizmi (see n. 27 below) but not in his *Geography*; the corrupt reading $29;15^\circ$ is recorded in a manuscript of the *Geography* of Suhrah—see Kennedy and Kennedy, *Coordinates*, 111 (*sub* KHZ and SUH). Or was the original value $29;15^\circ$ and the better value $29;55^\circ$ derived by a misreading? In any case, the latter was still used by al-Marrakushi (article in EI²) in Cairo ca. 1280. The late-10th-century astronomer Ibn Yunus (article in DSB) complained that some people in his time thought that the latitude of Cairo-Fustat was $29;0^\circ$ and that they were surprised that sundials based on this latitude did not work properly there. This value is associated with the astrologer Masha'allah (Fustat, ca. 780—article in DSB)—see Kennedy and Kennedy, *Coordinates*, 111 (*sub* MSH YAQ). Ibn Yunus seems to have been the first person to measure the latitude properly as $30;0^\circ$. Note that the 10th-century astrolabist who made #99 labelled one of his plates for ‘Misr’, meaning ‘Old Cairo’, that is, Fustat. And it is Fustat which appears explicitly in the gazetteer of Nastulus on #1030 (see Appendix 2a, no. 46), datable ca. 925. The new city of al-Qahira

there in the eighth century, according to the tenth-century bibliographer Ibn al-Nadim, that the Muslims first encountered the astrolabe.²⁴

We should be very careful in assigning localities to latitudes on the basis of our own geographical knowledge. There is a gazetteer on a mater by Nastulus (#1130, ca. 925),²⁵ unique amongst the surviving instruments before ca. 1100,²⁶ which can teach us a few lessons. Latitudes to the nearest degree are given for some 64 localities, Mecca and Medina at 21° and 24° and the rest between 30° and 37° except for Tiflis at 41°, the purpose surely being to show which plates one should use in the various localities, but alas no plates survive for this instrument. The data are presented in Appendix 2b, and most of the entries are derived from those of al-Khwarizmi, the most significant ninth-century geographer, who apparently took his data from a Ptolemaic world-map.²⁷ The data serve as a gentle reminder that we should not use modern latitudes to investigate medieval materials. Thus Nastulus on his other surviving astrolabe (#3501) has a single plate for 33° and 36°. I would have thought this would have been intended for Baghdad (and perhaps Damascus) and Mosul (with or without Aleppo). However, whilst we are in luck with 33°, Nastulus put Mosul at 35° and Aleppo at 34°. At 36° he has Massisa, Tarsus, Balad, Nisibin, Balis and Ardebil, but we do not need to choose between these because 36° is also the middle of C4 for the Ptolemaic value of the obliquity, used by Nastulus for the lengths of daylight on this plate.

In the case of two tenth-century Eastern Islamic astrolabes (#100 and #111) we find horary quadrants for a fixed latitude on the back:²⁸ on both the markings are for latitude 33°, which can only be for Baghdad. The maker of the first instrument, Hamid ibn 'Ali al-Wasiti, is known to have worked in Baghdad, but the maker of the second, the astronomer Hamid ibn Khidr al-Khujandi, is otherwise not known to have worked outside Rayy (near

(Cairo) was founded in the year 969, but astrolabists in eleventh-century Andalusia continued to use the expression *Misr*, meaning *Misr al-Qahira*, or Cairo-Fustat (see the article 'Misr' in EI², esp. 146-147).

²⁴ See, for example, King, 'Origin of the Astrolabe', 49-50 and 64-65.

²⁵ On the identity of the maker see King, *Islamic Astronomical Instruments*, IV and V (the second written together with Paul Kunitzsch).

²⁶ See n. 11 above.

²⁷ On al-Khwarizmi see the DSB article by Gerald Toomer. All studies relating to his Geography are repr. in *Islamic Geography*, vols. XI and XII. The values that are not based on al-Khwarizmi are of particular interest. Some can be shown to be based on variant readings of his entries, or on alternative entries in his tradition (Suhraib and Ibn Yunus). But most interesting of all are those values which seem to be derived from an early source for the monumental *Kitab al-Atwal wa-l-'urud*, an 11th- or 12th-century Iranian production which was to be highly influential in Iran for several centuries (see esp. King, *Mecca-Centred World-Maps*, Section 3.3). Since no author, location or secure date can be associated with this work, any scraps of information we can gather on it are welcome.

²⁸ See n. 10 above.

modern Tehran).²⁹ On #4022, an unsigned, undated piece, surely tenth century, there is an unlabelled quarter-circle on the trigonometric grid on the back: this can be used to find, for any solar longitude, the equation of half daylight for latitude 33°, which associates the piece with Baghdad. On #122, made in 1102/03 by a maker bearing the epithet al-Isfahani, there are three sets of markings in the upper right quadrant on the back: graphical representations of the solar altitudes at the *zuhr* and '*asr* prayers'³⁰ as well as the length of twilight for latitude 32° (presumably Isfahan, though note that Nastulus put it at 34°!),³¹ and a *mihrab* indicating the azimuth of the qibla at Isfahan (actually stated).³² The curves for the prayers are described already by al-Biruni (early eleventh century) in his treatise on shadows.³³ There are no other early Eastern Islamic astrolabes with markings of religious significance.

4. *All roads lead to Rome, but which Rome?*

The majority of surviving early Western Islamic astrolabes (post-dating the earliest that have markings for the climates) have lists of localities in the Iberian Peninsula and the Maghrib as well as in the Islamic East. The idea, which, as noted above, was possibly Byzantine in origin, may have come to Andalusia with a hypothetical late (Graeco-)Roman tradition of astrolabe-making, of which we seem to have one example, namely, #3042, from tenth-century Catalonia.³⁴ On this, one of the plates, for 41;30°, is marked 'Roma

²⁹ On al-Wasiti see Mayer, *Islamic Astrolabists*, 45, and on al-Khujandi the articles in EI² and DSB (also the confused remarks in Mayer, *op. cit.*, 45).

³⁰ These are defined by shadow-lengths, more specifically by the increases of the shadow over its minimum at midday. See Kennedy, *al-Biruni on Shadows*, Chapters 25-26, and my article 'Mikāt. Astronomical Aspects' [= astronomical timekeeping] in EI², repr. in King, *Astronomy in the Service of Islam*, V.

³¹ On Islamic twilight determinations see, for example, King, *Islamic Mathematical Astronomy*, London 1986, IX, 365-368, and the EI² article 'Mikāt'.

³² On the sacred direction in Islam see my article 'Kibla. Astronomical aspects' in EI², repr. in King, *Astronomy in the Service of Islam*, IX. A wide variety of instruments for determining the qibla is discussed in idem, *Mecca-Centred World-Maps*, Section 2.9.

³³ Kennedy, *al-Biruni on Shadows*, I, 236-238 (translation), and II, 147-148 (commentary). On al-Biruni see Kennedy's splendid article in DSB.

³⁴ This provenance was proposed by M. Destombes, and is accepted by P. Kunitzsch and J. Samsó as well as by the present writer. Various other opinions are expressed in *Oldest Latin Astrolabe*, eds. Stevens et al. J. Samsó and A. Mundó in their contributions to that volume discuss the meaning of Francia (which, as shown by Samsó, cannot be understood without reference to Islamic sources) and the distinctive forms of the letters in the engraving (which, as shown by Mundó, are all attested in other 10th-century Catalan inscriptions). In my contribution to that volume ('Earliest European Astrolabe') I compare numerous details on it with those on several dozen other Islamic and European pieces. Various aspects of it remain

et Francia', intended to serve the locale where the instrument was made (Francia here means Catalonia), and—I would maintain—the locale where this particular astrolabe tradition came from, namely, Rome. There are also markings for latitudes 36° (intended for Rhodes?, 'Africa?', C4?), 39° (Sicily?, Naples?, and/or Cordova?, C4/5?) and 45° (Vienne?, Po Valley?, C6?); the rationale behind those for 47;30° defies satisfactory explanation for the time being.³⁵

Amongst the geographical data on these early Western Islamic astrolabes we do indeed find mention of Rome, a city that one might think would have been of no consequence whatsoever for Muslims.³⁶ I would maintain that the inclusion of Rome provides another instance of the influence of this hypothetical (Graeco-)Roman tradition. No less interesting from a historical point of view, and of importance for the later history of medieval astronomy, even Byzantine astronomy, was the unfortunate association of Byzantium with the sixth rather than, more appropriately, the fifth climate. As a result of this error, Constantinople is often given a latitude of 45° (as on #3650 and #116, as well as in most geographical tables³⁷) rather than, say, 41°, which would be more reasonable.³⁸ There seem to me to be two possibilities:

(1) Either, there was a Roman tradition of astrolabe-making in which the plates were labelled for Rome, as well as, say, Sicily and Africa to the

inexplicable, hence my postulation of a hypothetical Roman tradition from which various features—including the design of the rete, the plate for Rome and the calendrical scale on the back with Roman month-names—may be derived (on 384 of my article the section beginning 'An astrolabe from ca. 1300' should be preceded by the words: 'Added in proof'). Islamic influence is apparent in the azimuth curves on the plates (first introduced in 9th-century Baghdad) and the alphanumerical notation used on the altitude scale and to represent the latitudes of the plates (which is based on the Western Islamic alphanumerical system, rather than, say, the Greek or Eastern Islamic ones).

³⁵ One possibility would be Heraclea Pontica on the Black Sea (Turkish Eregli), which Ptolemy put at 41;50° (actually 41°17') but which some early Muslim scholars put at 46;35° (close to C6/7) and 47;35° (possibly the result of a scribal error)—see Kennedy and Kennedy, *Coordinates*, 138-139. Note that in the two 15th-century European lists published in North, *Horoscopes and History*, 186-195, 'Eraclia' is still at 46;35° and there is an awkward gap between 46;50° (Cologne!) and 48;0° (Paris).

³⁶ One would, however, be wrong, because Muslims were fascinated by Rome: see El-Munajjed, 'Rome', and the article 'Rumiya' by R. Traini in *El*², mentioning the 'ambiguous geographical representation' of Rome by the Muslims, which goes back to Constantinople, and resulted from the influence of the Graeco-Byzantine and Syriac tradition. Also Western Islamic instrument-makers were not averse to using Arabicized forms of the Roman month-names on their calendar-scales—see Maier, 'Zeugen des Mehrsprachigkeit'.

³⁷ See Kennedy and Kennedy, *Coordinates*, 93-94, and also North, *Horoscopes and History*, 193.

³⁸ King, 'Astronomical Instruments between East and West', 169, and my remarks in a review of two recent publications on Byzantine astronomy published in *Isis* 82 (1991), 116-118, esp. 117-118. My friend Dr. Sonja Brentjes kindly drew my attention to the fact that this problem was noted by European scholars already in the 17th century—see *Curious Travels*, eds. Staphorst and Ray, II, 42-43.

south,³⁹ and various points north. In this case, the tenth-century Catalan astrolabe (#3042) with one plate for Rome (and Catalonia) is the main witness to this tradition.

(2) Or, there was no such tradition, and the Rome called *Rumiya al-kubra* at ca. 41;30° on some Andalusian astrolabes (#2527—see also #121, but compare #123, where it is called simply *Ruma*) was actually originally intended to be Constantinople.⁴⁰ In other words, the fact that Constantinople was given two different latitudes by medieval astronomers may have led to one of these ‘Constantinoples’ being interpreted as Rome by at least the maker of the Catalan astrolabe (#3042). And the *Rumiya al-kubra* on Andalusian astrolabes became Rome (as on #123) and Qustantiniyya remained Constantinople (as on #3650, #1216, and #4040).

5. *Astronomical observations and mathematical calculations reflected in the geographical data*

We find non-integral latitudes reflecting ninth-century observations, as in the case of 21;40° for Mecca (on #3650, #3622, etc.). This was the result obtained from measurements commissioned by the Abbasid Caliph al-Ma'mun. And some latitudes are not attested in any known medieval geographical tables: for example, 39;52° for Toledo, etc. on #117, which, however, just happens to be the accurate value for Toledo, and one can assume that some very competent astronomer actually derived it by careful observations.⁴¹

In the case of 33;9° for Baghdad (on #121, rounded to 33;10° on #117 and #2527), I suspect that this value might have been derived by calculation as the boundary of C3/4 using obliquity 24° (see Appendix 3).⁴² Certainly it is attested in ninth- and tenth-century Eastern Islamic geographical tables,

³⁹ Note that some medieval European astrolabes feature precisely these two regions: for example, the 13th(?)-century Catalan piece #416—see already King and Maier, ‘Catalan Astrolabe’, 694-695, n. 60.

⁴⁰ The very name *Rumiya al-kubra*, with the epithet *al-kubra*, ‘the greater’, applies in fact to Constantinople: see the article ‘Istanbul’ by H. Inalcik in EI², esp. 224a.

⁴¹ Compare North, *Horoscopes and History*, 192, with 15th-century values 39;54° and 39;58°, neither of which is known from the Islamic sources.

⁴² The value 33;9° is used in a limited number of early-9th-century tables (MS Oxford Marsh 663), whereas the value 33;21°, derived by observations, seems to have been more popular (MS Escorial ar. 932). On the other hand, the value 33;0° was also rather popular (see elsewhere in MS Oxford Marsh 663 and also King, ‘al-Khwarizmi’, 2).

having been used by al-Khwarizmi (*fl.* Baghdad ca. 825) and al-Battani (Raqqa ca. 910),⁴³ both of whose works were known in Andalusia.⁴⁴

With a value such as 38;30° for Cordova (on #3650, #116, *etc.* and in numerous geographical tables), better than Ptolemy's 38;50° but not as good as Theon's 38;5° (the accurate value is 37°53'),⁴⁵ we have no idea who first proposed it. It was possibly derived as the latitude of C4/5 using the Ptolemaic obliquity.

6. *Universality achieved by intense engraving*

Several early Western Islamic astrolabes contain a relatively large number of plates which display an impressive number of city-names alongside the latitudes, a veritable feat of engraving skills, even if some names had to be 'hyphenated' and continued on the next line (most unusual in Arabic). Mecca and Medina are now almost always included (#110 is an exception). Also there are invariably curves amongst those for the seasonal hours for the *zuhr* and the '*asr*' prayers, as well as altitude circles (below or above the horizon) for determining daybreak and nightfall, that is, for the *fajr* and '*isha*' prayers. The latitudes occasionally begin with the equator (see below), and below and up to Mecca sometimes include such exotic places as Ghana at 10;30° (on #116);⁴⁶ Hadramawt at 12;25° (on #3622); Sheba at 17;30° (on #3650, *etc.*);⁴⁷ the capital of China at 18° (on #2572);⁴⁸ Kuku at 21;40° (on #2527);⁴⁹ and al-Mansura 'in China' (actually in Sind) at 23° (on #4040). The majority of localities lie between latitudes 30° (Cairo, *etc.*) and 45° (Constantinople, *etc.*), and whilst cities in the Maghrib and Muslim Spain feature prominently, the makers were not averse to including such far away places as Bukhara and Samarqand. In addition to Rome (see above), we note the following localities outside the Islamic commonwealth: Cyprus, which

⁴³ On al-Khwarizmi see n. 27 above. On al-Battani see the DSB article by W. Hartner.

⁴⁴ Indeed, by an accident of history, they were the only two out of several dozen early Islamic astronomical handbooks that were transmitted to the West.

⁴⁵ Kennedy and Kennedy, *Coordinates*, 95; and King, *Islamic Astronomical Instruments*, XV, 374.

⁴⁶ A town in the Nigerian Sudan now vanished—see the article 'Ghana' in EI².

⁴⁷ Destroyed long before the advent of Islam, but mentioned in the Quran—see the article 'Saba'' in EI².

⁴⁸ This is probably Guangzhou (Canton)—see the article 'al-Sin' [= China] in EI², and also Kennedy and Kennedy, *Coordinates*, 91 (China, *etc.*) and 180 (Khanqu). Canton is actually at 22°8', but various early sources give 18;0°, 18;15° or 18;30° for the 'city' of China.

⁴⁹ A mythical place in Africa, whose name is written *K-w-k-w* or *K-w-k-h* (as on this astrolabe), sometimes put on the Nile, sometimes in Ghana, sometimes south of the equator. See Kennedy and Kennedy, *Coordinates*, 191-192.

inspite of numerous attacks still remained part of the Byzantine Empire, on #117; and Sardinia, whose inhabitants fought constantly to keep the Muslims out, and perhaps Marseilles (?—no photos available, perhaps my reading was in error), albeit at latitude 38;30°, so probably an error for Messina,⁵⁰ both on #2527.

It is worthwhile to seek a source for these geographical data amongst the several early sets of Islamic geographical tables,⁵¹ but this is an operation fraught with difficulty, not least in cases where the latitudes are expressed to the nearest degree. Also, some localities are given different latitudes, even by the same maker: thus, for example, Saragossa can be found at 41;30°, 42° and even 43;30°⁵² (#117, #3650, #116, #2527 and #1139).

We may anticipate that rarely-attested localities, distinctive latitude values, and errors of one sort or another⁵³ can provide the most clues. If we consider the unusual value 38;20° for Cordova on #117, we find that it is taken from al-Khwarizmi. So is the value 35;30° for Mosul, but not the 37;30° for Seville or 41;30° for Saragossa. Likewise, Tawiyus (possibly from Greek Takaphoris) occurs on #118 along with Qulzum at 28;20°. al-Khwarizmi and his heirs have 28;0°, but no other Islamic sources mention this locality. Also on #118 (as well as #4040), Tunis is given an absurd latitude of 33;0°, but this is precisely the value of al-Khwarizmi, rounded from that of Ptolemy. On #117, by the same maker, it is given the latitude 33;10°, but only because it is preceded by Baghdad, and the value here is simply rounded from al-Khwarizmi's 33;9°. On #2527 Homs has landed at 38;30°, which results from a scribal error for 33;30°, but al-Khwarizmi had 34;0°. On the same instrument (and on #1099) Anbar is at 37;30°, which results from a scribal error for 34;30°, given by Suhrah in the tradition of al-Khwarizmi.

Most of the Andalusian place-names are not in al-Khwarizmi (or al-Battani). We have already noted the value 39;52° for Toledo, which seems to be

⁵⁰ Kennedy and Kennedy, *Coordinates*, 218, gives for Marseilles only the Ptolemaic value 43;4°, an early Eastern Islamic value 43;0°, and 44;0° from the *Toledan Tables*. The value 38;30° for Messina is Ptolemaic: see *ibid.*, 228, and also North, *Horoscopes and History*, 192.

⁵¹ John North (*Horoscopes and History*, 186) has stated that the law of diminishing returns governs such undertakings, but this is, as the English say, a 'cop-out'. This is the sort of material on which doctoral candidates can be nurtured. On the other hand, I have refrained from organizing the Western Islamic data by place-name, which is not a cop-out but a favour to the editors of this volume.

⁵² This latitude is confirmed by the corresponding length of daylight. The accurate value is 41°39'.

⁵³ The alphanumerical notation used for numbers in astronomical and geographical tables led to different classes of numerical distortions (such as 3 ↔ 8, 10 ↔ 50, etc.). See Irani, 'Arabic Numeral Forms', on the notation, and King, *Mecca-Centred World-Maps*, Section 3.3.2, on the consequences.

the result of careful observations. There is also a serious value for Burgos, namely, 42° , on #154, which is not attested in the textual sources. Whilst it would be unwise to associate the latitudes of a given plate with each of the localities mentioned on the same plate, it is clear that in the early eleventh century someone did some serious thinking about the geography of Andalusia and that we have here some evidence of this activity. Now the first independent geographical table from Andalusia was prepared around the middle of the eleventh century by Ishaq ibn al-Hasan al-Zayyat.⁵⁴ This included some 300 entries and whilst being related to Eastern Islamic sources it did feature a relatively large number of localities in the Islamic West. But although this accounts for the inclusion of various localities on astrolabe-plates it does not always account for the latitudes accorded them. For example, al-Zayyat has $38;10^\circ$ for Cordova, 37° for Tunis and $43;0^\circ$ for Rome, and $10;15^\circ$ for Kuku, none of which values are found on the plates. In addition there are several localities featured on the plates which are not in al-Zayyat's list, such as Uclés and Calatrava. And sometimes when obscure places in the East appear, such as Siniz (near Ahwaz) at 30° (on #117 and #4040), it is not clear where the entry comes from, since both al-Khwarizmi and al-Zayyat have it. On the other hand, we note that whilst Santarém (with actual latitude $39^\circ 14'$) is at 42° on an early piece (#110), it is given al-Zayyat's better value 40° on two later ones (#3622 and #2527).

On the plate for latitude $35;30^\circ$ on #117 the more precise latitudes of seven localities are listed—see Appendix 2b. Of these values three are found in either al-Khwarizmi or al-Battani, three others are not attested in the Islamic sources (though one is Ptolemaic), and one is standard Islamic (though not in al-Khwarizmi or al-Battani). My enthusiasm upon noticing the values in November 1998 was somewhat dampened by these results.

In brief, the data on the Western Islamic astrolabes are a curious mixture of al-Khwarizmi (and hence ultimately Ptolemy) and al-Zayyat, a few new observed values for cities in Muslim Spain, and various roundings and mis-readings.

Added in proof: In January, 1999, I stumbled quite by chance across one of the sources of some of these geographical data. In the treatise on the *lámina universal* in the late-13th-century *Libros del saber de astronomía* of King Alfonso el Sabio, there is a geographical table for 21 localities, in al-Andalus, as well as Mecca and Medina. The table gives the latitudes, as well as the lengths of the longest day and shortest days—see Appendix 2c. For

⁵⁴ On al-Zayyat see Kennedy and Kennedy, *Coordinates*, xxxvii, and on the later fate of his tradition in Egypt see King, *Mecca-Centred World-Maps*, Section 2.6.3. There is a lot more to be said about al-Zayyat and his table.

Toledo we find, for example $39;52^\circ$, the distinctive value noted above. Note also that on #117 the shortest days are also given, precisely as in this table. The original Arabic treatise was by the celebrated astronomer al-Zarqallu (see DSB), and the table is dated 1067 AD (see King, *Islamic Astronomical Instruments*, VII, pp. 253-254).

7. *Universality by horizons alone*

The plate of horizons, with four sets of markings in each quadrant, the ensemble serving for a complete range of latitudes, was apparently introduced by Habash al-Hasib in the mid ninth century.⁵⁵ We first find such a plate on the astrolabe of al-Khujandi (#111), with underlying obliquity stated as $23;33^\circ$, the first value found by the astronomers of al-Ma'mun (although the daylight values on the plates are based on $23;51^\circ$). Likewise an Eastern Islamic set of plates (#4040) includes one for the horizons also indicating an obliquity of $23;33^\circ$.

8. *Astrological overtones*

Astrological information is found already occasionally on tenth-century Eastern Islamic astrolabes, such as that of al-Khujandi (#111).⁵⁶ Furthermore, a minority of surviving early Islamic Eastern and Western astrolabes have one or two additional plates marked for astrological purposes, presumably at least for the place where the instrument was made. Thus the same instrument (#111) has markings for the equalization of the houses and the casting of the rays⁵⁷ for an unspecified latitude, actually 33° , confirming the association with Baghdad (see above). The astrolabe of Ibrahim ibn al-Sahli (#121) has the same for $38;30^\circ$ and $41;30^\circ$, which must be for Cordova and Saragossa, as we see from the indications on the corresponding standard plates. That of Muhammad al-Sabban (#2527) has similar markings for Valencia and Saragossa, and an unsigned set of plates (#4040) the same for

⁵⁵ Morley, 'Astrolabe of Shah Husayn', 7, n. 12 (for Morley's Hanash read Habash).

⁵⁶ The similar markings on #3 were added later. This information, straight out of Ptolemy's *Tetrabiblos*, is usually presented in the form of scales giving the limits and their lords, the faces, and the lords of day and night and the companion for each zodiacal sign. See Hartner, 'The Principle and Use of the Astrolabe'.

⁵⁷ These are essentially markings for the seasonal hours above and below the horizon, but there are various modifications to this principle. See the article 'Tasyir' by O. Schirmer in EI², and North, *Horoscopes and History*, 56-69.

latitude 35°, apparently indicating that the maker favoured (or worked in) Ceuta or Tangiers.

9. *From the equator to the Arctic circle and beyond*

Markings for latitudes 0° and 90° first appear on the astrolabe of al-Khujandi (#111), serving pedagogic purposes and also satisfying intellectual curiosity: the associated lengths of daylight are stated as 12 hours and 6 months, respectively. On another Eastern Islamic astrolabe (#122) the markings are shown on the two halves of a single plate. Markings for latitude 0°, the equator, then appear on Western Islamic astrolabes (#3650, etc.), sometimes associated with Ceylon and the mythical islands of al-Yaqut and al-Jawhar.⁵⁸ An astrolabic plate for the latitude of the Arctic circle has the nice property that the horizon corresponds precisely to the ecliptic on the rete. Thus the astrolabic markings on the plate correspond to an ecliptic coordinate system, and they can therefore be used for converting ecliptic and equatorial coordinates, the latter represented—more or less—on the rete and surrounding scale. We find such a plate for the first time on the astrolabe of al-Khujandi (#111). Here the latitude is stated as 66;27°, implying an obliquity of 23;33°, the first value obtained by al-Ma'mun's astronomers. On an astrolabe made in Cordova in the eleventh century (#3622) the markings are associated with latitude 66;25°, underlying which is the second value obtained by these men, 23;35°, which was also accepted by al-Battani. (This, by the way, is the only one of the instruments discussed here in which there is any reference to the Creator as the force behind the subtleties of mathematical geography—see the quote at the beginning of this paper.) On the Western Islamic instruments of Muhammad ibn al-Saffar (#3650 and #116) the latitude 66° is stated, implying an approximation of the Ptolemaic value. On the latter we also find markings for latitude 72°, which can only have served pedagogic purposes.⁵⁹ The corresponding markings on another Western Islamic piece (#121) serve 66;30° and 72°.

⁵⁸ These were products of an uncontrollable desire to fill the gaps produced by the Indian Ocean in the sacred geography of a world centred on Mecca—see my article 'Makka. As centre of the world', in *El'*, repr. in King, *Astronomy in the Service of Islam*, X.

⁵⁹ Or was it perhaps originally thought of as the 'end' of the ocean surrounding the earth? See Kennedy and Kennedy, *Coordinates*, 248, where 71° is cited as the latitude of this extremity in a 15th-century source.

10. *A Ptolemaic surprise*

Of particular historical interest is the appearance amongst the plates of an eleventh-century Western Islamic astrolabe (#4040) of a plate for 16;30° south of the equator ('behind the equator in the south'), the value for 'Anti-Meroë' in Ptolemy's *Geography* and the lower limit of his world-map projections.⁶⁰ The existence of this plate is important evidence firstly that some knowledge of Ptolemy's *Geography* was available in Andalusia at the time of construction; and secondly that plates for southern latitudes were known in Andalusia in the eleventh century. Perhaps it was from Andalusia that the idea of representing southern rather than northern latitudes on the astronomical markings for astrolabic clocks came to medieval Europe.⁶¹ In any case, this plate serves as a reminder that astrolabe plates were not necessarily constructed so that travellers could use them.

Concluding remarks

We have seen how the climates of Antiquity influenced the geography of early Islamic instruments. Furthermore, we have seen that the geographical data on early Islamic astrolabes from the East and the West were different in format and in spirit, if not also in intended application.⁶² The large number of plates was not intended for practical purposes but to make the instrument universal.⁶³ The wide variety of information presented attests to an acute geographical awareness on the part of the Muslim instrument-makers, not always free from the limitations of blind traditionalism. They were also aware that the astrolabe is a model of the whole world—heavens and earth—that one can hold in one's hands. They made sure they did not neglect the terrestrial part of the instruments, namely, the plates, just as they rose to the challenge—in both scientific and artistic terms—of representing the fixed stars and sometimes even constellations on the celestial part, the rete. It is only when we have a clear idea of this that we can begin to understand what

⁶⁰ Neugebauer, *ESA*, 220-224, and idem, *HAMA*, II, 934-940.

⁶¹ On early European astronomical clocks see North, 'Monasticism and Clocks'.

⁶² We have noted that only on one relatively late Eastern Islamic astrolabe (#122) are there any markings for the prayer-times and the qibla, and that markings for the prayer-times were standard on Western Islamic astrolabes. But mind the gap: the Eastern instruments are mainly 10th century, and the Western ones mainly 11th century.

⁶³ See n. 12 above.

happened in the case of early European astrolabes,⁶⁴ which is far more complicated and not occasionally pathetic.⁶⁵ But that is another story.*

⁶⁴ For the significance and potential of this kind of information see already, for example, King and Maier, 'Catalan Astrolabe', 690-696 on #169 (where a latitude on a plate, probably derived by calculation, corresponds to the area of the dialect of medieval Catalan used for some star-names); King, 'Rewriting History through Instruments', 52 and 57, on #202 (where a latitude on a plate with special markings corresponds to the area of the Picard dialect of medieval French used for the month-names); King and Turner, 'Bessarion's Astrolabe', 186, on #640 (where a range of latitudes on a 15th-century astrolabe deemed suspect corresponds to that attributed to its maker by a 16th-century source); and Stautz, 'Astrolab aus dem Jahr 1420', 151-153, on #4523 (where the Northern Italian maker labelled his plates for latitudes 32°, 37°, 40°, 43°, 44°, 45° and 48°, but deviously constructed all of the markings for 45° (C6), that is, the Valley of the Po, where he felt most comfortable).

⁶⁵ A nice example is #191, a composite piece comprising a 14th(?) -century Northern Italian mater, fitted with a rete copied from or modified from an Western Islamic one, and containing two sets of plates, one Northern Spanish for integral latitudes 41° and 42° (marked 'Cesar Augusta' for Saragossa), 45°-50°, as well as 57°-58°, and the other Northern French for latitudes 45° and 48° (marked 'Parisius'). Now why would a Spanish astrolabist make a plate for 57° and 58°? Part of the answer is in the *Toledan Tables*, where the Island of Thule is reduced from Ptolemy's 63° to 58;10° (see also North, *Horoscopes and History*, 195). So why not make a plate for Thule? In fact, such a plate would have been about as useful to medieval European astronomers as ones for Kuku and Sheba would have been to their medieval Muslim counterparts. But it is still nice to have plates for such localities. We might also mention one English astrolabe-maker (responsible for #4518—see the illustration in King, 'Astronomical Instruments between East and West', 153) who lost control of his subject altogether when he labelled a plate for 48° with Thule and a plate for 58° with Paris. But now it really is time to stop.

* For reasons of efficiency the author has suggested the above spellings of Arabic names without diacritics—Eds.

APPENDIX 1

GEOGRAPHICAL DATA ON EARLY ASTROLABES (TO CA. 1100)

Key:

- Section in Appendix 4—Checklist number in Appendix 5—present location (abbreviations are in Appendix 5)
- Maker if named (b. = ibn, Ibr. = Ibrahim, M. = Muhammad)—Location of manufacture, if stated—Date, if given (usually converted from Hijra date), otherwise estimated

Density of altitude (H) and azimuth circles (A), above the horizon (A+) or below (A-)

- Obliquity underlying values of the length of longest daylight (only for Islamic astrolabes)
- The main data gives the climates or latitudes featured on the plates, with lengths of maximum daylight and names of localities. Where daylight values are given the errors in the minutes are shown in square brackets.

(a) *Byzantine astrolabes*

<i>1.1.1 - #2 - Brescia MEC</i>		<i>1.1.2 - #4509 - PC</i>	
Sergius the Persian, [Constantinople?], 1062		Unsigned, provenance?, undated (single plate)	
H/6°		H/2°	
-		-	
36°	C4Rhodes	[43°]	
40	C5Hellespont		
41	C5Byzantium		

(b) *Eastern Islamic astrolabes*

<i>1.2.1 - #3702 -</i>		C6	45	36	14;30	[0]
<i>Baghdad AM</i>		C7	48	<i>1.2.2c - #4030 - Florence</i>		
Reworked late 8th? /				<i>UG (illustration)</i>		
9th? C astrolabe, no		<i>1.2.2a - #1026 - Oxford</i>		Khafif, [Baghdad], undated		
original signature,		<i>MHS</i>		H/6°		
[Harran? / Baghdad?]		Khafif, [Baghdad],		23;51°		
H/6°		undated				
23;51°		H/6°		30 14 [+2]		
		23;51°		no more information avail-		
C1	16°			able (there were originally		
C2	24	33°	14;13h [0]	3 plates)		
C3	30	34	14;18 [-1]			
C4	36	35	14;22 [-2]			
C5	41			<i>1.2.3 - #99 - Paris BNF</i>		

Ahmad b. Khalaf,
[Baghdad], undated
H/6°, some A+/10°
23;51° (see below)

21°	Mecca	13;18	[0]
24	-	13;30	[-1]
29;55	Misr*	14	[+2]
31	-	14; 6	[+3]
34	-	-	
36	-	-	
37	Harran	14;36	[0]
39	-	15	[!]

* here meaning
Fustat—see the later
Andalusian sources
listed below where *Misr*
means Cairo-Fustat

1.2.4a - #3501 - *Kuwait*
DAI
Nastulus, [Baghdad],
315 H
H/6°
23;51°

33°	14;13	[0]
36	14;30	[0]

1.2.5 - #1179 - *PLU* <
Berlin PC
M. b. Shaddad, undated
markings?
?24° or ?23;51°?

11°	?	
21	13;19	[0/+1]

1.2.6 - #3522 etc. -
Rockford TM
al-Muhsin b. M.,
undated
H/6°
23;51°.
24° ? -
31 14;3 [0]

1.2.7 - #101 - *Florence*
MSS
Unsigned, undated
H/6°
23;51°

30°	14	[+2]
33	14;13	[0]

36	14;30	[0]
42	15	[-8]

1.2.8 - #4022 - *London*
SM

Unsigned, undated
H/6° (A+/10° are later
additions)
23;51°

24°	13;30	[-1]
28	13;47	[-2]
31	14; 4	[+1]
36	14;30	[0]
39	14;48	[0]

There was probably also
a plate for 33°

1.2.10 - #111 - *PC*
al-Khujandi,
[Baghdad?], 374 H
H/3°, some A+/5°, some
A-/5°
23;51° (and 23;33° for
plate serving 66;27°)

21°	13;18	[0]
27	13;44	[0]
30	13;58	[0]
33	14;13	[0]
36	14;30	[0]
39	14;48	[0]
42	15; 7	[-1]
66;27	24	[0]
0°/90°	12h/6m	[0]

Rays for 33°, horizons

1.2.11 - #3 - *Oxford*
MHS

The sons of Ibr. al-
Isfahani, [Isfahan?], 374
H
H/6°, one with A-/10°
23;51°

30°	14; 0	[+2]
31	14; 3	[0]
32	14; 8	[0]
34	14;19	[0]
36	14;30	[0]
42	15; 7	[+1]

some markings for
twilight

1.2.12 - #122 - *Florence*
MSS

M. al-Isfahani, [Isfahan],
496 H
H/6°, some A-/10°
23;51°

24°	13;31	[0]
30	13;56	[-2]
31	13;58	[-5]
32	14; 8	[0]
33	14;13	[0]
36	14;30	[0]
0°/90°	-	-

Note: The daylight for 31°
is accurate for 30°.

1.2.13 - #4021 - *Copen-*
hagen DS
Unsigned, undated
H/3° (ogival)
23;51°

36°	14;30	[0]
42°	15; 7	[-1]

1.2.14 - #4020 - *London*
PC
Damaged
markings?
n.a.

36°

1.2.15b - #109 = #3549 -
New York MMA

Unsigned, undated
H/6°
23;51° or 24°

C6 = 41°	15 ½
C7 = 48	16

There is a problem with
these markings. The
latitude of C6 is closer to
45°, which underlies the
markings. The latitude of
the seventh climate rounds
to 48° only for obliquity
24°; for lower values of the
obliquity it rounds to 49°.

<u>1.2.15c - #1026 -</u>	H/6°	36°	14;28	[-2/0]
<i>Oxford MHS</i>	23;51°?	or	41	15; 0
Unsigned, undated	23;33°/23;35°?			[-1/+2]

(c) *Western Islamic astrolabes*

Key (in addition to that given above):

Curves for prayers indicated by $z = \text{zuhr}$, $a = \text{'asr}$, $b = \text{end of 'asr}$

Curves for twilight indicated by t+ (above horizon) or t- (below it)

1.3.1 - #4024 - illustrated in MS Paris	14;30	12;52	[-1]	Sanaa
BNF 7412	17;30	13; 4	[0]	Sheba
Khalaf b. al-Mu'adh, undated (10th century)	21;40	13;22	[+1]	Mecca
H/6°	25	13;35	[0]	Medina
23;51°	28	13;49	[0]	Qulzum
	30	13;59	[+1]	Misr (Cairo-Fustat)
	32	14; 8	[0]	Kairouan
C1 13 16;27° [0]	34;20	14;20	[-1]	Samarra
C2 13 1/2 23;16 should be 23;49	36	14;30	[0]	Tangiers
C3 [14] 30;22 [+1]	38;30	14;45	[0]	Cordova
C4 14 1/2 36; 6 should be 36;1	40	14;54	[0]	Toledo
C5 15 40;56 [+3]	42	15; 8	[0]	Saragossa
C6 15 1/2 45; 1 [0]	45	15;30	[0]	Constantinople
C7 16 48;32 [+1]				

Also 66° - - -

1.3.2 - #110 = #135 - London BM

Unsigned, undated

H/6° and A+/10°, some z, a, t+

—

30° *Misir* (Cairo-Fustat), Kirman,
Siraf
36 Almería, Harran, Samarqand,
Tarsus
38;30 Cordova, Tudmir (Murcia), Ibiza
40 Toledo, Valencia, Denia, Badajoz
42 Saragossa, Medinaceli, Santarém

1.3.3a - #3650 - Edinburgh RSM

M. b. al-Saffar, Cordova, 417 H

H/6° and A+/10°

On the plate for 17;30° (the only one I have seen) there are curves for the *zuhr* and the beginning and end of the *'asr*, and the altitude circle at 18° is marked for twilight.

23;51°

0°	12	[0]	Equator, the Island of Cey- lon, the Island of al-Yaqut and al-Jawhar
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1.3.3b - #116 - Marburg Berlin SBOA

M. b. al-Saffar, Toledo, 420 H

H/6° and A+/10°, z, a, b, some t

23;51°

[0°]	[12; 0]	[0]	The Island of Ceylon, the Island of al-Yaqt
10;30	12;38	[0]	Ghana
14;30	12;52	[-1]	Sanaa
17;30	13; 4	[0]	Sheba
21;40	13;20	[-1]	Mecca
25	13;35	[0]	Medina
28	13;49	[0]	Qulzum
30	13;58	[0]	<i>Misr</i> (Cairo-Fustat)
32	14; 8	[0]	Kairouan
34;20	14;20	[-1]	Samarra
36;30	14;33	[0]	Samarqand
38;30	14;45	[0]	Cordova
40	14;54	[0]	Toledo
43;30	15;18	[0]	Saragossa
45	15;30	[0]	Constantinople
66/72	-	-	-

Rays for $38;30^\circ$ and 42°

1.3.3c - #4025 - Palermo MN

[M. b. al-Saffar], undated				38;30	14;45	[0]	Cordova, Valencia
H/6° and A+/10°, z, a, b				40	14;54	[0]	Toledo, Santarem
40° Toledo				42	15; 8	[0]	Saragossa
H/5° and no A				* Clearly a scribal error for 13;58, which is accurate			
[42;30°] -							
<i>1.3.4 - #3622 - Cracow JUM</i>				66;25°	24	[0]	inscription—see the quote at beginning of this paper
Unsigned, Cordova, 446 H							
H/3° and A/5°, z, a, t-				<i>1.3.5b - #1079 - Palermo MN (stolen)</i>			
23;51°				Ibr. b. 'Abd al-Karim, undated			
12;25° 12;45 [0]				H/6° and A+/10°			
21;40 13;21 [0]				20° ?			
24 13;30 [-1]				? ?			
27 13;44 [0]				30 <i>Misr</i> (Cairo-Fustat)			
30 13;53* [-5]				? 739 ?			
32 14; 8 [0]				Caldo mentions the mater (for 30°) and 2			
36;30 14;30 [-3]				plates for latitudes between 20° and 39°.			
<i>1.3.6a - #117 - Madrid MAN</i>							
Ibr. b. Sa'id al-Sahli, Toledo, 459 H							
H/3° and A/5°							
23;51°							
22° 13;21/10;39		[-1]	Mecca				
25 13;35/10;25		[0]	Medina				
30 13;58/10;2		[0]	<i>Misr</i> (Cairo-Fustat), Kirman, Sijilmasa, Siniz, Janaba				
32 14;8/9;52		[0]	Kufa, Sijistan, Jerusalem, Tiberias, Carthage, Shiraz, Alexandria, Fars, Ascalon, Rosetta, Tinnis, Ramla, Ahwaz, Kairouan, Ana, Tripoli (Libya), Barqa (! repeated), Istakhr, Gaza				
33;10 14;14/9;46		[0]	Baghdad, Damascus, Fez, Babil, Tunis (!), Hit, Barqa (! repeated), Salé, Acre				
35;30 14;15/9;45		[!]	Mosul, Rusafa, Manbij, al-Mada'in, Cyprus, Sicily, Ceuta (the latitudes in degrees and minutes of each of these localities are given above the names—see Appendix 2b)—the length of daylight should be 14;27				
36;30 14;33/9;27		[0]	Almería, Algeciras, Harran, Ra's al-'Ayn, Shahrazur, Samaraqand				
37;30 14;39/9;21		[0]	Seville, Málaga, Granada, Tudmir (Murcia), Sardinia, Shimshat, Edessa, al-Rayy				
38;20 14;45/9;15		[+1]	Cordova, Baeza, Murcia, Jaen, Balkh, Jurjan				
39;52 14;54/9;6		[+1]	Toledo, Talavera, Madrid, Calatrava, Uclés, Cuenca, Guadalajara, Azerbaijan, Akhlát				
41;30 15;5/8;55		[+1]	Saragossa, Calatayud, Daroca, Lérida, Huesca, Barbastro				
<i>1.3.6b - #118 - Oxford MHS</i>							
Ibr. b. Sa'id al-Sahli, Toledo, 460 H							
H/5° and A/9°, some z, a, b, t+							
23;51°							
21;40° 13;20,40		[-15"]	Mecca, Yamama				

25	13;35	[0]	Yathrib = Medina
28;20	13;50	[0]	Qulzum, Madyan, Kabul, Tawiyus, Dalas
30	13;58	[0]	<i>Misir</i> (Cairo-Fustat), 'Ayn Shams (Heliopolis), Kirman, Kandahar, Mahruban
33	14;13	[0]	Baghdad, Damascus, Caesariya, Tunis (!), Fez
35;30	14;27	[0]	Mosul, Rusafa, Manbij, Sicily, Ceuta
36;30	14;33	[0]	Almería, Harran, Samarqand, Ra's al-'Ayn, Shahrazur
37;30	14;39	[0]	Seville, Málaga, Granada, Bukhara, Edessa, Rayy
38;30	14;45	[0]	Cordova, Murcia, Baeza, Jaen, Marwarrudh, Balkh, Jurjan
40	14;54	[0]	Toledo, Talavera, Azerbaijan, Akhlát
41;30	15; 5	[+1]	Saragossa, Calatayud, Huesca, Barbastro

1.3.6c - #123 = #1167 - Rome OA

Ibr. b. Sa'id al-Sahli, Valencia, 463 H

A/3° and A/6°, z, a

23;51°

22	13;22	[0]	Mecca
25	13;35	[0]	Yathrib = Medina
28;20	13;50	[0]	Qulzum, Fayyum, Ahnas, Kabul, Tawiyus, Dalas
30	13;58	[0]	<i>Misir</i> (Cairo-Fustat), Kirman, Qandahar, 'Ayn Shams (Heliopolis), Mahruban
35;00	14;27,30	[+27!!!]	Tangiers, ?, Sicily, Manbij, ?, Mosul, Rusafa, ?
36;30	14;33	[0]	Almería, Harran, Samarqand, Ra's al-'Ayn, Shahrazur
37;30	14;39	[0]	?, ?, ?, ?, Mayyafariqin, ?
38;30	14;45	[0]	Cordova, Murcia, Baeza, Marwarrudh, Balkh, Jurjan
40	14;54	[0]	Toledo, ?, ?, Azerbaijan, Akhlát
41;30	15; 5	[+1]	Saragossa, Calatayud, Lérida, Rome (<i>Ruma</i>), Khwarizm

Two additional sets of markings, of which at least the second is by another maker

33 14;13 [0] Baghdad, Damascus

34;30 - - Tlemcen

Plate of horizons, plate with trigonometric grids, possibly not original

Some localities are illegible on the available photos

1.3.7 - #121 - Kassel SKS

Ibr. b. al-Sahli, Valencia, 478 H

H/6° and A+/10°, z, a, b, t+

23;51°

0°	12	[0]	'what is below the celestial equator', the Island of Ceylon, the Island of al-Yaqut and al-Jawhar
13	12;47	[0]	Aden
19	13;10	[0]	Yemen, Tabala
22	13;22	[0]	Mecca
25	13;35	[0]	Yathrib = Medina
30	13;58	[0]	<i>Misir</i> (Cairo-Fustat), Kirman, Mahruban
32	14; 8	[0]	Kairouan, Ascalon, Tiberias
33; 9	14;13	[-1]	Baghdad, Damascus, Caesariya
35;30	14;27	[0]	Manbij, Sicily, Ceuta, Mosul
36;30	14;33	[0]	Almería, Harran, Shumayshat, Samarqand (!)
37;30	14;39	[0]	Seville, Málaga, Granada
38;30	14;45	[0]	Cordova, Murcia, Baeza
39;30	14;50	[-1]	Valencia, Denia, Badajoz, Merida
40	14;54	[0]	Toledo, Calatrava, Uclés

41;30 15; 8 [+4] Saragossa, Rome, Khwarazm

Also 66;30° and 72°

Rays for latitudes 38;30° and 41;30°

1.3.8a - #2527 - Oxford MHS

M. b. Sa'id al-Sabban, Guadalajara, 474 H

H/6° and A+/10°, t+, some t-, z, a, b

21;40° Mecca, Yamama, Taif, Kuku

30 *Misr* (Cairo-Fustat), Kirman, Madyan, *al-xmdxxh* (where x represents an unpointed carrier) (??)

31;30 Alexandria, Kufa, Basra, Damietta, Sabur, *Bistam* (??!)

33;10 Baghdad, Fez, Damascus, Ascalon, Ifriqiyya, Tunis (!!)

36;30 Almería, Samarqand, Ra's al-'Ayn, Harran, Tarsus, Massisa, Raqqa, Hamadan

37;30 Granada, Málaga, Sardinia, Azerbaijan, Nishapur, Anbar (!), Bukhara, Edessa

38;30 Cordova, Salobrena, Seville, Marseilles, Ibiza, Homs (!)

39;30 Valencia, Badajoz, Denia, Malatya

40 Toledo, Santarem

42 Saragossa, Tortosa, Rome (*Rumiyya al-kubr[a]*)

Rays for Saragossa and Valencia

1.3.8b - #1139 - Munich BNM

M. b. Sa'id al-Sabban, 466 H

H/6° and A/10°, t+, t-, z, a

-

21;30° Mecca, Yamama

30 *Misr* (Cairo-Fustat), Tarsus (!!), Kirman (misspelled)

32 Kairouan, Kufa, Tiberias

33 Baghdad, Jerusalem

35;30 Ceuta, Sicily, Mosul, Rusafa

36;30 Almería, Málaga, Ra's al-'Ayn, Samarqand

37;30 Seville, Granada

38;30 Cordova, Murcia, Baeza, Jaén

39;30 Valencia, Badajoz, Denia

40 Toledo, Azerbaijan

41;30 Saragossa, Lérida

1.3.9 - #2572 - Washington NMAH

M. b. al-Sahli, Valencia, 483 H

H/6° and A/10°

23;51°

0° Equator (daylight 12h)

18 The (capital) city of China

21;30 Mecca

24 Medina

27 Akhmim

36 Almería, C4

37;30 Seville, Málaga, Granada
(daylight 14;39h [0])

42 Saragossa

66 -

Seasonal hours are labelled animal, vegetable or mineral.

1.3.10 - #4040 - PC

Unsigned, undated

H/6° and A/9°, z, a, b, t+

23;33°—see below

16;30° SOUTH 'behind the equator in the south, latitude 16;30°'

23 Mecca, Jedda, Taif, Yamama, Siraf, al-Mansura in China (!)

25 Yathrib = Medina, Hajar, Bahrein

30 *Misr* (Cairo-Fustat), Kirman, Siniz (near Ahwaz), 'Ayn Shams (Heliopolis)

32 Kairouan, Tiberias, Ascalon,

Alexandria

33 Baghdad, Hit, Damascus, Tunis (!), Salé

35 Ceuta, Tangiers, Sicily, Mosul, *m-l-w-f-r* (?)

36 Almería, Harran, Samarqand, Ra's al-'Ayn

37;30 Seville, Málaga, Granada, Bukhara, Rayy

38;30 Cordova, Marseilles (!! maybe my misreading of Messina), Marwar-rudh, Balkh, Jurjan

45 Constantinople, Burjan (???)

Astrological houses for latitude 35°.
Plate of horizons bears a scale showing
obliquity 23;33°

1.3.11 - #1099 - Focus Behaim Globus
Ahmad b. M. al-Naqqash, Saragossa, 472
H
H/6° and A/9°, some z, a, b, t- added later

21;30° Mecca, Taif, Yamama, Beja
25° Medina
31° Alexandria, Damietta, Shapur
33° Baghdad, Damascus, Fes,
Ascalon
34;30° Menorca (!), Aleppo (!), Antioch
(!), Basra (!)
35° Ceuta, Sicily, Mosul, Rusafa
36;30° Almeria, Samarqand, Harran,
Ra's al-'Ayn
37;30° Seville, Granada, Anbar (!)
38;30° Cordova, Jaén, Jurjan, Balkh
39;30° Valencia, Badajoz, Majorca
41;30° Saragossa, Huesca, Calatayud

1.3.12a - #2572 - Washington NMAH

Unsigned, undated
H/6° and A+/10°, z, a, t+, t-

37° Granada and 38° Seville (on the
same plate !)
38;30° Cordova

Seasonal hours marked animal, vegetable
and mineral

1.3.12c - #154 - Chicago AP

Unsigned, undated
H/6° and A/10°, t-
23;51°

Toledo	40°	14;51	[-3]
Burgos	42	15; 8	[0]

(d) *Earliest European astrolabes (selected)*

6.1.1 - #3042 - Paris
IMA
Unsigned, [Catalonia],
undated [10th C]
H/6° and A/+°

36 -

39 -

41;30° *Roma et Francia*
45 -
47;30° -

6.1.2 - #161 - London
BM
Unsigned, provenance
uncertain, undated [13th?
C]
H/?°

15° - 23° - 30° - 36° -
41° - 45° - 48°

6.1.3 - #166 - Oxford
MHS

Unsigned, provenance
uncertain [Italy?],
undated [13th C]
H/3° or H/6°

C1	12
C2	24
C3	30
C4	36
C5	41
C6	45
C7	48

6.1.4 - #300 - Oxford
MHS
Unsigned, provenance
uncertain [England?], un-
dated [13th? C]
H/6° and A/10°

25° - 30° - 35° - 40° - 45°
- 48° - 52° - 55° - 60°

6.1.17 - #589 -
Bernkastel-Kues NKS
Unsigned, [Germany?],
undated [13th C?]
H/?

C1	15°
C2	24
C3	30
C4	36

C5	41
C6	45
C7	48

6.1. - #416 - Greenwich
NMM
Unsigned, [Catalonia],
undated [13th C?]

Damietta	4	31°
Jerusalem	3	32
Africa	4	33
Tripoli	4	34
Ceuta	4	35
Sicily	5	38
Valencia	5	39
Segovia	5	40
Barcelona	6	41
Pamplona	6	42
Macedonia	3	43
Genoa	3	44
Milan	2	45
unnamed*	7	46

* actually markings are
for [41°]

Notes: The place-names
are in medieval Catalan.

The information on the climates is confused.

6.2.2 - #558 - *Focus Behaim Globus*

Unsigned, provenance uncertain, undated [13th? C]

H/3° and A/10° or
A/7;30°

16° - 30° - 36° - 40° -
45° - 48° - 52°

6.3.1 - #162 - *London SA*

Unsigned, [Catalonia],
undated [13th C?]

H/5° and A/10°

32;30° [Jerusalem]
38;30 [Cordova]
39;40 [Valencia]
41 [Barcelona?],
C5?
42 [Gerona?]

6.3. - #4560 - *PC*
Unsigned, [Toledo?], un-
dated [14th C]
H/6° and A/10°

32;30° [Jerusalem]
40 [Toledo?]
42 [Saragossa?]
43 [?]
45 [Vienne?, Lyon?]
49;30 [Reims]

One original plate is
missing; a replacement
plate has inscriptions in
Arabic and serves Algiers
[ca. 35;30°] and [Mecca,
ca. 21;30°]

6.4. - #202 - *PC*
Unsigned, [Picardy], un-
dated [14th C]
H/5° and A/15°

24° - 30° - 36° - 41° - 45°
48° - 50° - 51°

APPENDIX 2

A) THE GAZETTEER ON THE UNDATED MATER BY NASTULUS
(#1030)

The single-letter abbreviations for sources listed below are used instead of the three-letter ones in Kennedy and Kennedy, *Coordinates*. For more details the reader must consult that publication. Since the majority of the latitudes presented by Nastulus agree with what one could expect from al-Khwarizmi's geographical table, my main task has been to find possible sources for those which do not. The symbol Ø indicates that there is no value in source K (see below). Values which round to those given by Nastulus (he appears to have favoured rounding 30' downwards) and which *may* have been used by him are printed in italic font. Entries marked ⊕ are discussed further in the notes after the tables. Particularly problematic entries are boxed.

Symbol	Source
A	ATH The 11th- or 12th-century Iranian table labelled <i>Kitab al-Atwal wa-l-'urud</i> (clearly some entries in our table are derived from one of its early sources)
B	BAT al-Battani (ca. 910)
G	BAG al-Baghdadi (ca. 1280), derived from B and related to Q
H	HAB Habash al-Hasib (ca. 850) - see nos. 1 and 2 below
K	KHU al-Khwarizmi (ca. 825), the major source for our table
K+	Variant readings of K (Kb: KHU BAT; Kh: KHU HON; Kr: RSM FID; Kz: KHZ)
M	MSH Masha'allah (ca. 780), only for Egypt
P	PTO Ptolemy, from which K is ultimately derived
Q	QBL al-Dimyati (Cairo, 12th? century), based on earlier sources, related to B and G
S	SUH Suhrah (10th century), based on K
T	SAA Ibn Sa'id al-Maghribi (Maghrib, 13th century)
Y	YUN Ibn Yunus (Cairo, late 10th century), based mainly on K
Z	- most or all (other) early sources (to ca. 950)

Locality	φ	Comments
1 Medina	24°	KZB 25;0° - H 24;0°
2 Mecca	21	KZH 21;0
3 Tiflis	41	KØ - Z 42;0 / 43;0
4 Qum	35	KZ 35;40 - B 36;0 - A 34;45
5 Nishapur	37	K 37;0
6 Shutar	32	KØ - A 31;30
7 Istakhr	32	K 32;0
8 Farama	31	KB 31;30 - S 31;20
9 Alexandria	31	K 31;5

10 Ifriqiya	36	KØ - B 31;0 - ⊕
11 Massisa	36	K 36;0
12 Adana	35(!)	KØ - Z 36;45 / 36;50
13 Tarsus	36	K 36;55 - S 37;35 - Y 36;15 - ⊕
14 Nihawand	34	KZ 36;0 - A 34;30
15 Hulwan	34	K 34;0
16 Baghdad	33	K 33;9 - Kz 33;0 - S 33;25
17 Samarra	34	K 34;0

18 Tikrit	34	KØ - S 35;8 - A 34;30	55 Kirman	30	K 30;0
19 Haditha	35	K 34;20 (Ana) - S 32;0 (al-H) - A 33;35 / 36;0 - ⊕	56 Shiraz	31(!)	KKz 32;0 - S 31;0
20 Mosul	35	KZ 35;30	57 Fars	32	P 33;20 - KØ - B 32;0 - ⊕
21 Balad	36	K 36;20	58 Sus	32	KB 34;0 - A 32;15
22 Erzerum	37	KØ - Kr 39;15 - A 41;0	59 Ahwaz	32	K 32;0
23 Akhlat	37	KZ 39;50	60 Basra	31	K 31;0
24 Mayyafariqin	37	K 37;55 - Kh 37;15 - ⊕	61 Wasit	32	K 32;20
25 Amid	35	KØ - Kb 37;52 - S 34;40 - A 37;0	62 Mada'in	32	KS 33;0 - B 35;55 - A 33;10
26 Tell Mawzan	37	KØ - BQ 37;0 - ⊕	63 Babil	32	PB 35;0 - KØ - A 32;15
27 Ra's al-'Ayn	37	K 37;0	64 Kufa	32	KKz 31;50
28 Nisibin	36	K 36;0			
29 Hit	33	K 33;15			
30 Ana	34	K 34;20			
31 Qarqisiya	35	K 35;20			
32 Raqqa	36	K 36;0			
33 Damascus	33	K 33;0			
34 Edessa	37	K 36;40			
35 Harran	37	K 36;40			
36 Aleppo	34(!)	KS 34;30 - Kz 33;30 - A 35;50			
37 Manbij	35	KKz S 35;30			
38 Antioch	35	K 34;10 - Kz 33;10 - S 35;0			
39 Balis	36	K 36;0			
40 Homs	33	KS 34;0 - Kz 33;10			
41 Ascalon	33	K 33;0			
42 Tiberias	32	K 32;0			
43 Ramla	32	KS 32;40 - Kz 32;15 - A 32;10			
44 Jerusalem	32	K 32;0			
45 Gaza	32	K 32;0			
46 Fustat	30	K 30;0			
47 Tinnis	31	M 31;0 - KKr 31;40 - S 32;30 - A 30;40 - ⊕			
48 Kairouan	31	KSA 31;40 - T 31;0 - ⊕			
49 Dinawar	34	KØ - S 34;0			
50 Hamadan	35	KKzS 36;0 - A 35;0			
51 Qazwin	37	K 37;0			
52 Isfahan	34(!)	KKrKz 34;30 - S 34;0 - A 32;40			
53 Rayy	35	KKrKz 35;45 - SA 35;35			
54 Ardebil	36	KØ - S 40;0 - A 38;0 - G 36;0 - ⊕			

Additional notes:

- 10 - This is the first of two entries for provinces rather than cities (see also no. 32). K has 33;0° for Tunis and 31° for Kairouan (see no. 48).
- 13 - ϕ : 36° could have been derived from 36;15° and the value we have for K is perhaps a copyist's error (see also no. 24).
- 19 - There are three localities in Iraq called Haditha and the sources are confused. A is the first to distinguish between those on the Euphrates and Tigris, giving 33;35° and 36;0°, respectively (modern 34°9' and 35°;59').
- 24 - ϕ : 37° could have been derived from 37;15° and the value we have for K is perhaps a copyist's error (see also no. 13).
- 26 - Only B and Q give this value, and the locality does not occur in any other source.
- 32 - This is the second entry for a province (see no. 10), and al-Battani can hardly have been to Fars to measure its latitude.
- 47 - KKrS have Tinnis in the Med, M is not bad for the 8th century, A is too low (modern 31°15').
- 48 - T is a 13th-century table, and perhaps this value occurred in one of its sources.

B) THE LATITUDES ON THE PLATE FOR 35;30° IN THE MADRID
ASTROLABE OF IBRAHIM IBN SA'ID AL-SAHLI (#117)

Mosul	35;30°	attested in al-Khwarizmi et al.
Rusafa	35;40	attested in al-Battani et al.
Manbij	35;30	attested in al-Khwarizmi et al.
Mada'in	35;30	Ptolemaic, not attested in the Islamic sources
Cyprus	35;10	not attested
Sicily	35;30	not attested
Ceuta	35;20	standard Islamic value but not in al-Khwarizmi or al-Battani

C) THE GEOGRAPHICAL TABLE IN AL-ZARQUALLU'S TREATISE
DE LA LÁMINA UNIVERSAL

From *Libros del saber*, ed. Rico y Sinobas, 1873, III, p. 53.

Locality	ϕ	daylight	
		max	min
Toledo, Talavera, Madrid, Calatrava, Uclés	39;52°	14;54 ^h	9; 6 ^h
Saragossa, Calatayud, Daroca, Lérida, Huesca, Barbastro	41;30	15; 5	8;55
Cordova, Baeza, Murcia, Jaen	38;20	14;45	9;15
Seville, Málaga, Granada, Tudmir	37;30	14;39	9;21
Almería, Algeciras	36;30	14;33	9;27
Medina	25; 0	13;35	10;25
Mecca	22; 0	13;21	10;39

APPENDIX 3

THE LATITUDES (ϕ) OF THE MIDPOINTS AND BOUNDARIES OF
THE SEVEN CLIMATES (C1-C7), DEFINED IN TERMS OF THE
LENGTH OF MAXIMUM DAYLIGHT (D), FOR DIFFERENT VALUES
OF THE OBLIQUITY OF THE ECLIPTIC (ϵ)

$\epsilon =$	24°	23;51	23;35	23;33	23;31	23;30	23;28
Climate	D	ϕ					
	12;45 ^h	12;25°	12;30	12;39	12;40	12;42	12;43
C1	13; 0	16;20	16;27	16;39	16;40	16;42	16;43
	13;15	20; 6	20;14	20;28	20;30	20;31	20;32
C2	13;30	23;40	23;49	24; 5	24; 7	24; 9	24;10
	13;45	27; 1	27;11	27;29	27;31	27;33	27;35
C3	14; 0	30;10	30;21	30;40	30;42	30;45	30;46
	14;15	33; 6	33;17	33;37	33;40	33;42	33;44
C4	14;30	35;50	36; 1	36;22	36;25	36;27	36;28
	14;45	38;21	38;33	38;54	38;57	38;59	39; 1
							39; 2

C5	15; 0	40;41	40;53	41;14	41;17	41;20	41;21	41;22
	15;15	42;50	43; 2	43;24	43;26	43;29	43;30	43;32
C6	15;30	44;49	45; 1	45;22	45;25	45;28	45;29	45;31
	15;45	46;38	46;50	47;12	47;15	47;17	47;19	47;20
C7	16; 0	48;19	48;31	48;53	48;55	48;58	48;59	49; 1
	16;15	49;52	50; 4	50;25	50;28	50;31	50;32	50;33

Note on the values of ϵ : Indians: 24°; Ptolemy: 23;51° (rounded); Muslim astronomers (9th and 14th centuries): 23;33°; Muslim astronomers (9th century and thereafter): 23;35°; al-Tusi (ca. 1250) and Ibn al-Shatir (ca. 1350): 23;31°; Ulugh Beg (ca. 1425): 23;30° (rounded); Ottoman astronomers (16th century and thereafter): 23;28°.

APPENDIX 4

LIST OF SURVIVING GREEK AND EARLIEST ISLAMIC
AND SOME EARLIEST EUROPEAN ASTROLABES

Notes: This list has been extracted and adapted from the table of contents of the new catalogue of medieval instruments (not restricted to astrolabes) now in preparation in Frankfurt. The list contains only the earliest instruments and therefore omits Islamic astrolabes after ca. 1100 and most medieval European astrolabes but for some of the earliest. This list should not be quoted by the section numbers (e.g. §1.2.1), which are not yet finalized, but rather by the corresponding International Instrument Checklist Number (e.g. #3702). Numbers up to #4000 are from Gibbs et al., *Checklist*; numbers above that (to #9999) have been assigned by the present author (see Appendix 5). The following abbreviations are used:

AM	Archaeological Museum (Baghdad)	MIA	Museum of Islamic Art (Cairo)
AP	Adler Planetarium (Chicago)	MMA	Metropolitan Museum of Art (New York)
BM	British Museum (London)	MN	Museo Nazionale (Palermo)
BNF	Bibliothèque nationale de France (Paris)	MSS	Museo di Storia della Scienza (Florence)
BNM	Bayerisches Nationalmuseum (Munich)	NKS	Nicolaus Kusanus-Stift (Bernkastel-Kues)
DAI	Dar al-Athar al-Islamiyya (Kuwait)	NMAH	National Museum of American History (Washington, D.C.)
DS	Davids Samling (Copenhagen)	NMM	National Maritime Museum (Greenwich)
GNM	Germanisches Nationalmuseum (Nuremberg)	OA	Osservatorio Astronomico (Rome)
IGN	Institut für Geschichte der Natur- wissenschaften (Frankfurt)	PC	private collection
IMA	Institut du Monde Arabe (Paris)	PLU	present location unknown
JUM	Jagiellonian University Museum (Cracow)	RSM	Royal Scottish Museums (Edinburgh)
KC	Nasser D. Khalili Collection (London)	SBOA	Staatsbibliothek Preußischer Kul- turbesitz, Orientabteilung (Berlin)
DB	Dar Bahtha' (Fez)	SKS	Staatliche Kunstsammlungen (Kassel)
MAN	Museo Arqueológico Nacional (Madrid)	SM	Science Museum (London)
MC	Merton College (Oxford)		Time Museum (Rockford, Ill.)
MEC	Museo dell'Età Cristiana (Brescia)	UG	Uffizi Galleries, Gabinetto dei Disegni e Stampi (Florence)
MHS	Museum of the History of Science (Oxford)		

1 *Early Eastern astrolabes (to ca. 1500)*1 *Byzantine astrolabes*

- 1 An astrolabe dated 1062 (#2 - Brescia MEC)

- 2 Miscellaneous items
 - a) A single plate (#4509 - PC)
 - b) Markings on an Abbasid plate (#109 = #3549 - New York MMA)
- 2 *The earliest Eastern Islamic astrolabes (9th-11th centuries)*
 - 1 A late (Ottoman?) astrolabe signed by Ahmad ibn Kamal, copied (or possibly remodelled) from an early Abbasid astrolabe (#3702 - Baghdad AM)
 - 2 Three instruments by Khafif, apprentice of 'Ali ibn 'Isa
 - a) An undated astrolabe (#1026 - Oxford MHS)
 - b) A solitary rete (#2529 - Oxford MHS)
 - c) Parts of an astrolabe illustrated in a 16th-century Italian drawing (#4030 - Florence UG)
 - 3 An undated astrolabe by Ahmad ibn Khalaf (#99 - Paris BNF)
 - 4 Two instruments by (Muhammad ibn 'Abdallah known as) Nastulus
 - a) An astrolabe dated 315 H (#3501 - Kuwait DAI)
 - b) An undated mater (with various Mamluk Egyptian additions dated 714 H) (#1130 = #4023 - Cairo MIA)
 - 5 An undated astrolabe by Muhammad ibn Shaddad (al-Baladi) with a later Maghribi rete (#1179 - PLU, formerly Berlin PC)
 - 6 An undated astrolabe by al-Muhsin ibn Muhammad al-Tabib (#3522 = #3527 = #3904 = #3919 - Rockford TM)
 - 7 An unsigned undated Abbasid astrolabe with later (19th-century?) additions by a European (the so-called 'Astrolabe of Pope Sylvester II') (#101 = #9001 - Florence MSS)
 - 8 An unsigned mater and plates (#4022 - London SM)
 - 9 Two instruments by Hamid ibn 'Ali (al-Wasiti)
 - a) A mater dated 343 H (#100 - PLU < Palermo MN - stolen ?)
 - b) A mater with an illegible date [3]74 H (with a replacement rete and plates) (#3713 - Cairo MIA)
 - 10 An astrolabe by Hamid ibn Khidr al-Khujandi dated 374 H (#111 - Kuwait PC)
 - 11 An astrolabe by Ahmad and Muhammad, sons of Ibrahim al-Isfahani, dated 374 H and fitted with a replacement rete datable to ca. 1100 (#3 - Oxford MHS)
 - 12 An astrolabe by Muhammad ibn Abi l-Qasim al-Isfahani al-Salihani dated 496 H (#122 - Florence MSS)
 - 13 A solitary Abbasid plate with ogival markings (#4021 - Copenhagen DS)
 - 14 A badly-corroded Abbasid (?) astrolabe (#4020 - London PC)
 - 15 Miscellaneous items
 - a) A solitary rete (#2529 - Oxford MHS)
 - b) A solitary plate (#109 = #3549 - New York MMA)
 - c) A single plate (#1026 - Oxford MHS)
- 3 *The earliest Western Islamic astrolabes (10th and 11th centuries)*
 - 1 An astrolabe by Khalaf ibn al-Mu'adh illustrated in a Latin manuscript (#4024 - Paris BNF)
 - 2 An unsigned, undated astrolabe with a rete in the early Andalusian Abbasid style (and additional markings by a European) (#110 = #135 - London BM)
 - 3 Some instruments by Muhammad ibn al-Saffar
 - a) A mater and plates dated 417 H (with a later Eastern Islamic rete) (#3650 - Edinburgh RSM)
 - b) An astrolabe dated 420 H (#116 - Berlin SBOA)
 - c) A solitary plate (#4025 - Palermo MN)
 - 4 An unsigned Andalusian astrolabe dated 446 H, with later inscriptions in Catalan (#3622 - Cracow JUM)
 - 5 Two instruments by Ibrahim ibn 'Abd al-Karim
 - a) A mater dated 458 H (#3714 - Fez DB)
 - b) An undated astrolabe (#1079 - Palermo MN - stolen)

- 6 Three astrolabes by Ibrahim ibn Sa'id ibn Asbagh al-Ansari *thumma* al-Sahli al-Mawazini
 - a) Dated 459 H (#117 - Madrid MAN)
 - b) Dated 460 H (#118 - Oxford MHS)
 - c) Dated 463 H (#123 = #1167 - Rome OA)
- 7 An astrolabe by Ibrahim ibn al-Sahli dated 478 H (#121 - Kassel SKS)
- 8 Two astrolabes by Muhammad ibn Sa'id al-Sabban
 - a) Dated 474 H (#2527 - Oxford MHS)
 - b) Dated 496 H or 466 H (#1139 - Munich BNM)
- 9 An astrolabe by Muhammad ibn al-Sahli dated 483 H, with a replacement rete bearing Hebrew inscriptions (#2572 - Washington NMAH)
- 10 Some 11th-century Andalusian plates (in a composite Ottoman astrolabe) (#4040 - PC)
- 11 An astrolabe by Ahmad ibn Muhammad al-Naqqash dated 472 H (#1099 - Focus Behaim Globus)
- 12 Miscellaneous items
 - a) A single plate (#2572 - Washington NMAH)
 - b) An isolated plate (#4025 - Palermo)
 - c) A single plate (#154 - Chicago AP)

6 *Early European astrolabes (to ca. 1500) [selected]*

1 *Miscellaneous early European astrolabes (I)*

- 1 An astrolabe from 10th-century Catalonia (the 'Carolingian astrolabe') (#3042 - Paris IMA)
- 2 An astrolabe for the seven climates (#161 - London BM)
- 4 An English or French astrolabe for latitudes between 24° and 60°, including for [Paris] and [London] (#300 - Oxford MHS)
- 5 An Italian astrolabe with plates for the climates (#166 - Oxford MHS)
- 6 An Italian astrolabe with plates for the climates (#167 - London BM)
- 7 A French astrolabe with plates for the upper climates (#420 - Greenwich NMM)
- 9 An Italian astrolabic plate for the second climate and a simplified rete combining northern and southern projections (#169 - Oxford MHS)
- 16 An English mater with plates for the climates (#303 - Oxford MC)
- 17 A mater and plates for the climates owned by Nicolaus of Cusa (#589 - Bernkastel-Kues NKS)
 - A Catalan astrolabe (#416 - Greenwich NMM)

2 *Miscellaneous early European astrolabes (II)*

- 2 An astrolabe of uncertain provenance for latitudes between 16° and 52° (#558 - Focus Behaim Globus)

3 *Astrolabes with quatrefoil ornamentation (I)*

- 1 A Catalan astrolabe with a rectangular frame inside the ecliptic on the rete (#162 - London SA)
 - A Spanish astrolabe with additional inscriptions in Arabic and Hebrew (#4560 - PC)

4 *Astrolabes with quatrefoil ornamentation (II)*

- 6 A Picard astrolabe with numbers engraved in monastic ciphers (#202 - PC)

8 *English astrolabes with V- or Y-shaped frames on the rete*

- An English astrolabe with confused markings on the plates (#4518 - PC)

APPENDIX 5

LIST OF INSTRUMENTS CITED IN THE TEXT

Note: The numbers denoted by the symbol # are those of the International Instrument Checklist (for medieval and Renaissance instruments) currently in preparation. Numbers from 1 to 3999 are those of Gibbs et al., *Checklist*. New numbers are assigned as follows: 4001-4999 for additional astrolabes, 5001-5999 for quadrants, 6001-6999 for sundials, 7001-7999 for globes; 8001-8999 for miscellaneous; and 9001-9999 for fakes. The numbers preceded by § refer to the new catalogue of medieval instruments currently in preparation in Frankfurt (see Appendix 4) and are not yet definitive. Instruments with numbers less than #337 are treated in Gunther, *Astrolabes of the World*. Other references are to literature in which the object in question has been catalogued or described in detail. For abbreviations in the statements of the provenance see Appendix 4.

- #2 Brescia, MEC, inv. no. 36—Byzantine astrolabe dated 1062 (§1.1.1)—see Gunther, *Astrolabes of the World*, I, 104-108 (no. 2), based on Dalton (1926).
- #3 Oxford, MHS, inv. no. IC 3—astrolabe by Ahmad and Muhammad, sons of Ibrahim al-Isfahani, dated 374 H and fitted with a replacement rete datable to the 12th century (§1.2.11)—see Gunther, *Astrolabes of the World*, I, 114-116 (no. 3).
- #99 Paris, BNF, inv. no. Ge. A.324—astrolabe by Ahmad ibn Khalaf (Baghdad, 10th century) (§1.2.3)—see Gunther, *Astrolabes of the World*, I, 230 (no. 99).
- #100 PLU, stolen from Palermo, MN—mater by Hamid ibn ‘Ali dated 343 H (§1.2.9a)—see Mortillaro (1848), reprinted in AIOS, I, 162-191, and the more accurate account in Caldo, ‘Astrolabi di Palermo’, 6-9 (inadvertently omitted from AIOS).
- #101 Florence MSS, inv. no. 1113—unsigned undated Abbasid astrolabe with later (19th-century?) additions by a European (the so-called ‘Astrolabe of Pope Sylvester II’) (§1.2.7)—see Gunther, *Astrolabes of the World*, I, 230-232 (no. 101).
- #109=#3459 New York, MMA, inv. no. 91.1.535—astrolabe by the Yemeni Sultan al-Ashraf dated 690 H (containing an Abbasid plate with additional markings in Greek) (§1.1.2a, 1.2.15b, 1.5.12)—see King, *Islamic Astronomical Instruments*, II.
- #110=#135 London, BM, inv. no. OA+371—unsigned, undated astrolabe (10th century) with a rete in the early Andalusian ‘Abbasid’ style (and additional markings by a European) (§1.3.2)—see Gunther, *Astrolabes of the World*, I, 244 (no. 110) and 280 (no. 135).
- #111 Kuwait, PC—astrolabe by Hamid ibn Khidr al-Khujandi dated 374 H (§1.2.10)—see King, ‘Kuwait Astrolabes’, 80, 82, 83-89 (no. 2).
- #116 Berlin, SBOA, inv. no. 6567 (Sprenger 2050)—astrolabe by Muhammad ibn Saffar, dated 420 H (§1.3.3b)—see Gunther, *Astrolabes of the World*, I, 251-252 (no. 116), after Woepcke (1858), reprinted in AIOS, II, 1-36.
- #117 Madrid, MAN, inv. no. 50762—astrolabe by Ibrahim ibn Sa‘id al-

- Sahli dated 459 H (§1.3.6a)—see Gunther, *Astrolabes of the World*, I, 252-253 (no. 117), and García Franco, *Astrolabios en España*, 229-235 (no. 12).
- #118 Oxford MHS, inv. no. IC118—astrolabe by Ibrahim ibn Sa'id al-Sahli dated 460 H (§1.3.6b)—see Gunther, *Astrolabes of the World*, I, 253-256 (no. 118).
- #121 Kassel, SKS, inv. no. A38—astrolabe by Ibrahim ibn al-Sahli dated 478 H (§1.3.7)—see Gunther, *Astrolabes of the World*, I, 263 (no. 121).
- #122 Florence, MSS, inv. no. 1105—astrolabe by Muhammad ibn Abi l-Qasim al-Isfahani al-Salihani dated 496 H (§1.2.12)—see Gunther, *Astrolabes of the World*, I, 263 (no. 122).
- #123 Rome, OA, inv. no. ?—astrolabe by Ibrahim ibn Sa'id al-Sahli dated 463 H (§1.3.6c)—unpublished.
- #135 See #110.
- #154 Chicago, AP, inv. no. M-36—astrolabe by Muhammad ibn Yusuf ibn Hatim, dated 638 H (§1.6.3), with a spurious plate (§1.3.12c)—see Gunther, *Astrolabes of the World*, 300 (no. 154), and the forthcoming catalogue of the AP astrolabes.
- #161 London, BM, inv. no. 1961 12-1 1—unsigned, undated astrolabe for the seven climates (§6.1.2)—see Gunther, *Astrolabes of the World*, I, 306 (no. 161); and *London BM Catalogue*, 110 and 112 (no. 323).
- #162 London, SA, inv. no. Cat. 559—astrolabe with a rectangular frame inside the ecliptic on the rete and plates for latitudes down to that of [Palestine] (§6.3.1)—see Gunther, *Astrolabes of the World*, I, 306-309 (no. 162), based on Read (1893), and, more recently, King and Maier, 'Catalan Astrolabe'.
- #166 Oxford, MHS, inv. IC 166—Italian astrolabe with plates for the climates (§6.1.5)—see Gunther, *Astrolabes of the World*, I, 316-317 (no. 166).
- #167 London, BM, inv. no. 67 7-5 22—Italian astrolabe for the climates (§6.1.6)—see Gunther, *Astrolabes of the World*, I, 317 (no. 167); and Ward, *Catalogue*, 114 (no. 329).
- #169 Oxford, MHS, inv. no. IC 169—unsigned, undated Italian astrolabic plate for the second climate and a simplified rete combining northern and southern projections (§6.1.9)—see Gunther, *Astrolabes of the World*, I, 319-320 (no. 169).
- #191 Oxford, MHS, inv. no. IC 191—Spanish (?) astrolabe (for Saragossa and other latitudes, with later additions for Paris) (§6.2.4)—see Gunther, *Astrolabes of the World*, I, 340-341 (no. 191).
- #202 PC—late-14th-century Picard astrolabe bearing monastic ciphers, with an inscription by Berselius dated 1522 (§6.4.6)—see King, 'Rewriting History through Instruments'; and idem 'A Forgotten Number-Notation of the Cistercians'.
- #291 London, BM, inv. no. 1909 6-17 1—Anglo-French astrolabe with plates for Montpellier, Oxford and elsewhere, dated 1326 (§6.6.2)—see Gunther, *Astrolabes of the World*, I, 465-467 (no. 291); and *London BM Catalogue*, 112-113 (no. 325).
- #300 Oxford, MHS, inv. no. IC 300—English or French astrolabe for latitudes between 24° and 60°, including for [Paris] and [London] (§6.1.4)—see Gunther, *Astrolabes of the World*, I, 477-478 (no. 300).
- #303 Oxford, MC—English mater with plates for the climates (§6.1.16)—see Gunther, *Astrolabes of the World*, I, 482 (no. 303).
- #416 Greenwich, NMM, inv. no. A21/NA36-21c—unsigned, undated (13th-century?) Catalan astrolabe (§6.1.1)—unpublished; see King and Maier, 'Catalan Astrolabe', 694-695.

- #420 Greenwich, NMM, inv. no. 39.693.A43—French astrolabe for the upper climates (§6.1.7)—unpublished.
- #558 Nuremberg, GNM, inv. no. WI 282—astrolabe of uncertain provenance with plates for latitudes from 16° to 52° (§6.1.14)—see King, 'Nürnberger Astrolabien', II, 574-576 (no. 1.72).
- #589 Bernkastel-Kues, NKS, inv. no. 3—mater and plates for the climates owned by Nikolaus of Cusa (§6.1.17)—see Hartmann, 'Instrumente'.
- #640 PC—astrolabe dedicated by Ioannes (Regiomontanus) to Cardinal Bessarion in 1462 (§6.9.3)—see King and Turner, 'Bessarion's Astrolabe'.
- #1026 Oxford, MHS, inv. no. 57-84/155—undated astrolabe (10th century) by Khafif (§1.2.2a)—see Maddison, *Supplement*, 16-18 (no. 155).
- #1079 Palermo, MN, inv. no. ? (stolen)—an undated astrolabe by Ibrahim ibn 'Abd al-Karim (§1.3.5b)—unpublished.
- #1099 Nuremberg, GNM, inv. no. WI 353—astrolabe by Ahmad ibn Muhammad al-Naqqash dated 472 H (§1.3.11)—see King, 'Nürnberger Astrolabien', II, 568-570 (no. 1.70).
- #1130 Cairo, MIA, inv. no. ?—an undated mater by Nastulus (§1.2.4b)—unpublished.
- #1139 Munich, BNM, inv. no. 33/243—astrolabe by Muhammad ibn Sa'id al-Sabban dated 496 H or 466 H (§1.3.8b)—see Stautz, *Münchener Astrolabien*, 145-159 (no. 1).
- #1167 See #123.
- #1179 PLU, formerly Berlin PC—undated astrolabe (10th century) by Muhammad ibn Shaddad (al-Baladi) with a later Maghribi rete (§1.2.5)—see the description by Dorn (1865), reprinted in AIOS, I, 345-498, esp. 461-464.
- #2527 Oxford, MHS, inv. no. 57-84/157—astrolabe by Muhammad ibn Sa'id al-Sabban dated 474 H (§1.3.8a)—see Maddison, *Supplement*, 18-19 (no. 157).
- #2529 Oxford, MHS, inv. no. 57-84/156—a solitary rete attributable to Khafif (§1.2.2b)—see Maddison, *Supplement*, 18 (no. 156).
- #2572 Washington, NMAH, inv. no. 318178—astrolabe by Muhammad ibn al-Sahli dated 483 H with a replacement rete bearing Hebrew inscriptions (§1.3.9)—see Gibbs and Saliba, *Astrolabes*, 174-177 (no. 2752) (with illustrations of the front and back) (and my review in *Isis* 77 (1986), 711-713), and Goldstein and Saliba, 'Astrolabe with Hebrew Star Names' (with more illustrations), particularly on the Hebrew inscriptions on the rete.
- #3042 Paris, IMA, inv. no. AI 86-31—unsigned, undated astrolabe from Catalonia, late or early 10th century (§1.6.1)—see *The Oldest Latin Astrolabe*, and *From Baghdad to Barcelona*, II, 655-672.
- #3459 See #109
- #3501 Kuwait, DAI, inv. no. LNS 36M—astrolabe by (Muhammad ibn 'Abdallah known as) Nastulus, dated 315 H (§1.2.4a)—see King, 'Kuwait Astrolabes', 79-83 (no. 1).
- #3522 = #3527 = #3549 = #3904 = #3919 Rockford, TM, inv. No. 507—undated (10th-century?) astrolabe by al-Muhsin ibn Muhammad al-Tabib (§1.2.6)—see *Time Museum Catalogue*, 60-63 (no. 1).
- #3527 See #3522.
- #3549 See #3522.
- #3622 Cracow, JUM, inv. no. 4037-35/V—unsigned Andalusian astrolabe dated 446 H, with later inscriptions in Catalan (§1.3.4)—see, most recently, Maier, 'Astrolab aus Córdoba'.
- #3650 Edinburgh, RSM, inv. no. T1959-62—mater and plates Muhammad ibn al-Saffar dated 417 H, fitted with a later Eastern Islamic rete

- (§1.3.3a)—unpublished.
 #3702 Baghdad, AM, inv. no. 9723—an early (8th- or 9th-century?) astrolabe with some replacement markings probably by Ahmad ibn Kamal, whose name is engraved on the throne in the same late Ottoman hand (§1.2.1)—see Stautz, ‘Früheste Formgebung’, with references to an earlier study by Fransis and Naqshbandi.
 #3713 Cairo, MIA, inv. no. 15352—mater by Hamid ibn ‘Ali with an illegible date [3]?4 H with a replacement rete and plates (§1.2.9b)—unpublished.
 #3714 Fez, DB, inv. no. ?—a mater by Ibrahim ibn ‘Abd al-Karim dated 458 H (§1.3.5a)—unpublished.
 #3904 See #3522.
 #3919 See #3522.
 #4020 London, PC—a badly-corroded 10th?-century Eastern Islamic astrolabe (§1.2.14)—unpublished.
 #4021 Copenhagen, DS—a solitary 10th?-century Eastern Islamic plate with ogival markings (§1.2.13)—unpublished.
 #4022 London, SM, inv. no. 1981-1380—an unsigned, undated (10th-century?) Eastern Islamic astrolabe (§1.2.8)—see *Linton Collection Catalogue*, 83, no. 160.
 #4023 See #1130.
 #4024 Paris, BNF, manuscript lat. 7412, fols. 19v-23v—astrolabe by Khalaf ibn al-Mu‘adh illustrated in a Latin manuscript (§1.3.1)—see Van De Vyver, ‘Premières traductions’; Destombes, ‘Astrolabe carolingien’, 23 and 41-43; and Kunitzsch, ‘10th-Century Astrolabe’.
 #4025 Palermo, MN, inv. no. ?—a solitary plate attributable to Muhammad ibn al-Saffar (§1.3.3c)—unpublished.
 #4030 Florence, UG, inv. no. U1454A recto and verso—drawing by Antonio da Sangallo the Younger (1520) of an astrolabe by Khafif (§1.2.2c)—see Saliba, ‘Drawing of an Astrolabe by Khafif’.
 #4040 PC, Belgium—a set of plates from an 11th-century Andalusian astrolabe—see *London Sotheby’s 30.5.1991 Catalogue*, 136 (lot 391).
 #4509 PC, Belgium—a medieval European astrolabe with a single plate with markings in Byzantine Greek (§1.1.2a)—unpublished.
 #4518 PC, Belgium—a medieval English astrolabe (§6.8.♦)—unpublished.
 #4523 PC, Germany—a Northern Italian astrolabe dated 1420—see Stautz, ‘Astrolab aus dem Jahr 1420’.
 #4560 PC—a 14th-century Spanish astrolabe with additional inscriptions in Arabic and Hebrew—see A. Turner, ‘Astrolabe exceptionnel’ / ‘Exceptional Astrolabe’ (preliminary description), and King, ‘14-th Century Spanish Astrolabe’.

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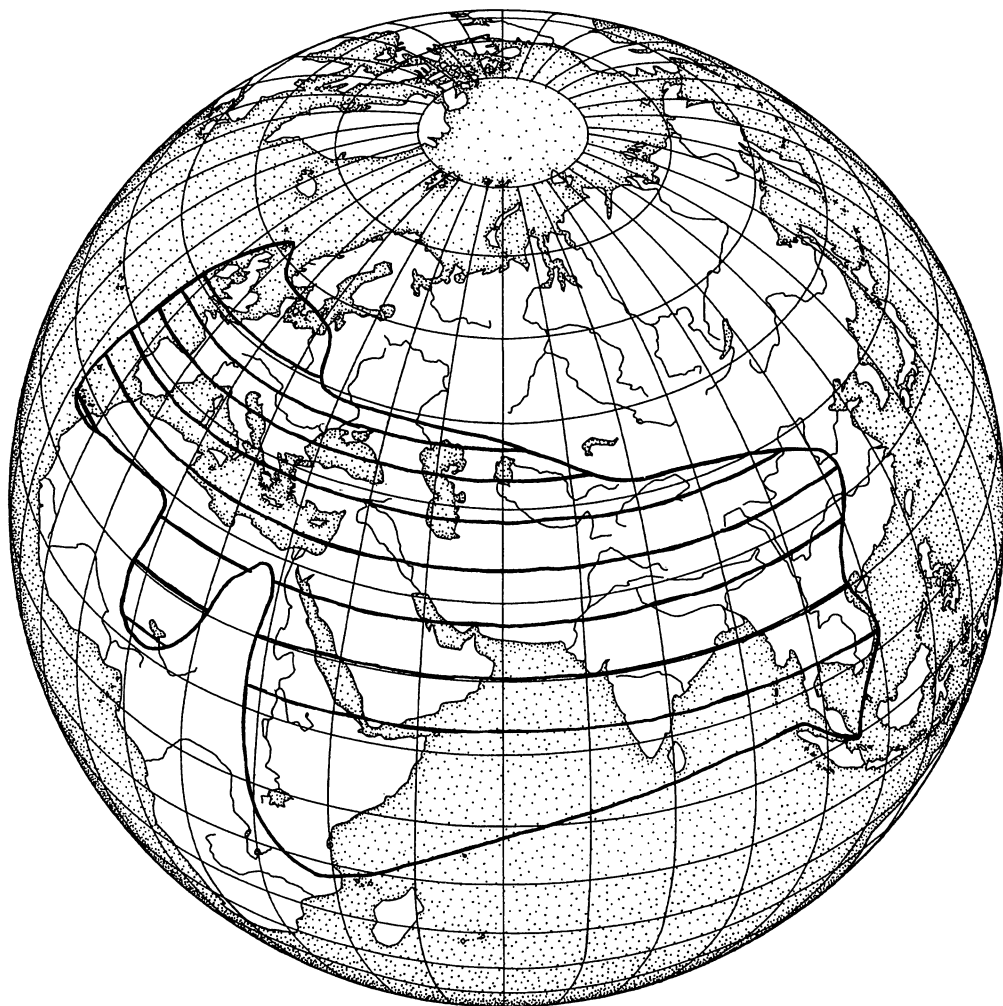


Figure 1 The climates of Antiquity shown within the boundaries of the world as known to Ptolemy. The influence of the climates in medieval geography, astronomy, and instrumentation has been much underestimated in modern scholarship. [Courtesy of a student at Frankfurt University who left this with me without leaving his name.]

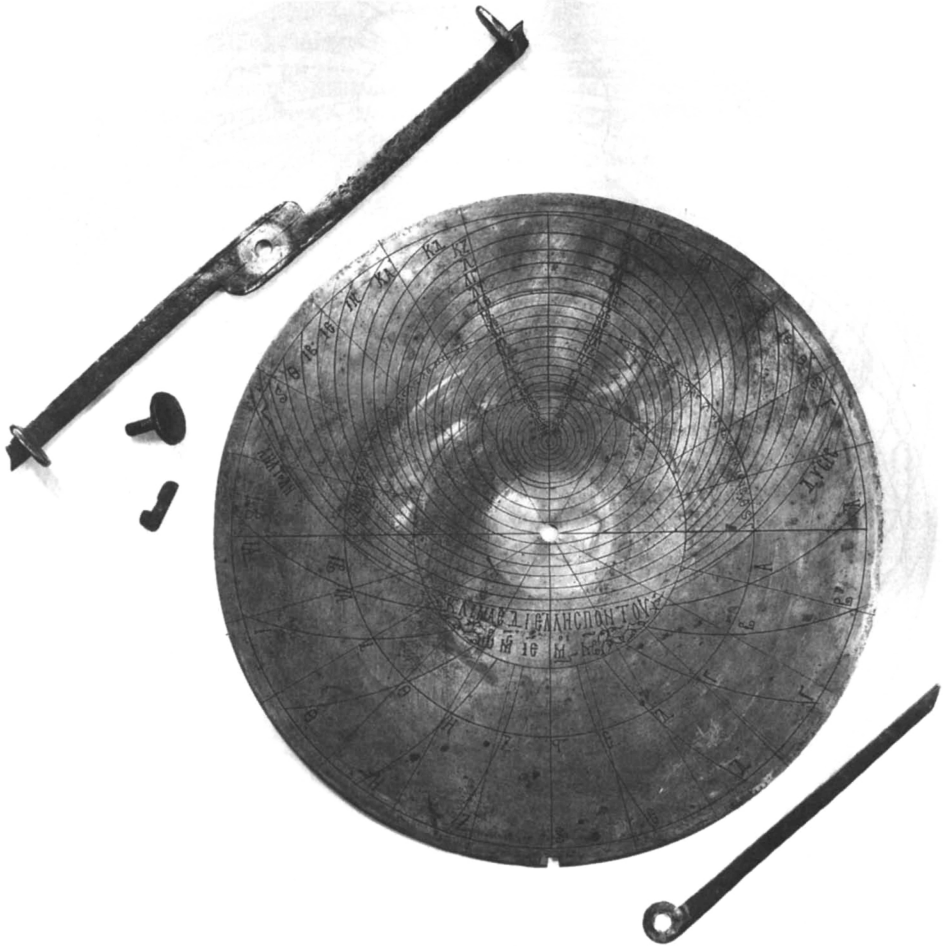


Figure 2 The plate for Hellespont with latitude 40 in the 4th climate on the sole surviving Byzantine astrolabe, dated 1062 (#2). Note the higher density of altitude circles between the two solstitial circles for timekeeping by the sun and the radial markings for the equinoctial hours, both features rarely found on Islamic or European astrolabes. [Photo courtesy of the Museo dell'Età Cristiana.]

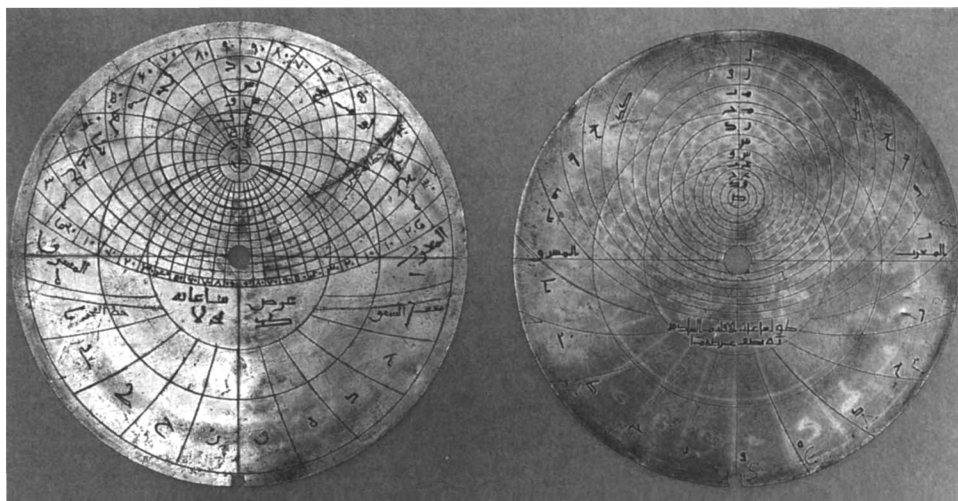


Figure 3 Inside a 13th-century Yemeni astrolabe (#109) we find a series of plates for various latitudes in the Yemen and the Hejaz, such as the one shown here on the left for 24, serving Medina. In addition, however, there is a spurious early Islamic plate (9th or 10th century?), shown here on the right. This has markings for latitude 45, and the inscription reads: ‘The length of the hours in the 6th climate is 15 and a half and the latitude is 41 (sic)’. Only the earliest Eastern Islamic astrolabes had plates for the climates. On this plate the seasonal hours are also labelled in capital Greek alphanumerical notation. [Photo courtesy of the Metropolitan Museum of Art, New York.]

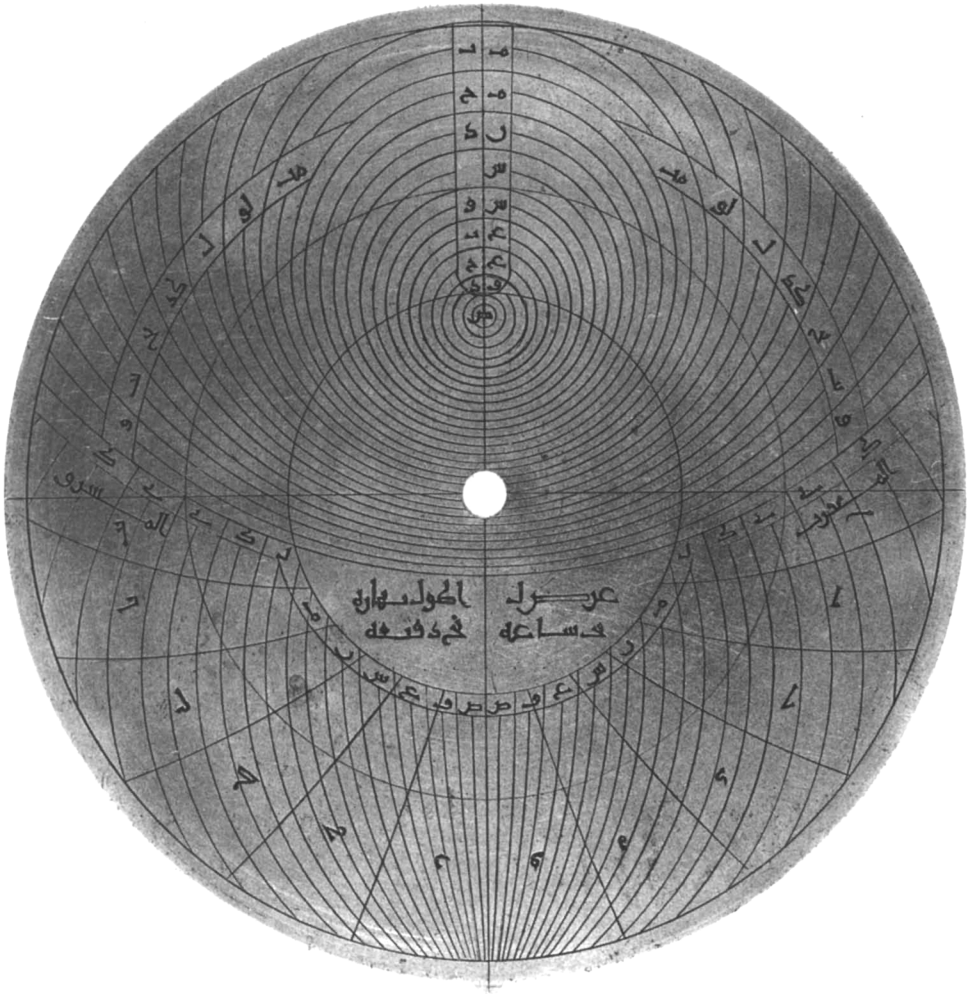


Figure 4 One of the plates of the splendid astrolabe of the astronomer al-Khujandi, made in Baghdad in 984/85 (#111). This plate, which serves latitude 30, has azimuth curves below the horizon, so as to separate them from the altitude circles above the horizon, and the altitude and azimuth arguments engraved in cartouches. [Private collection, photo courtesy of the owner.]

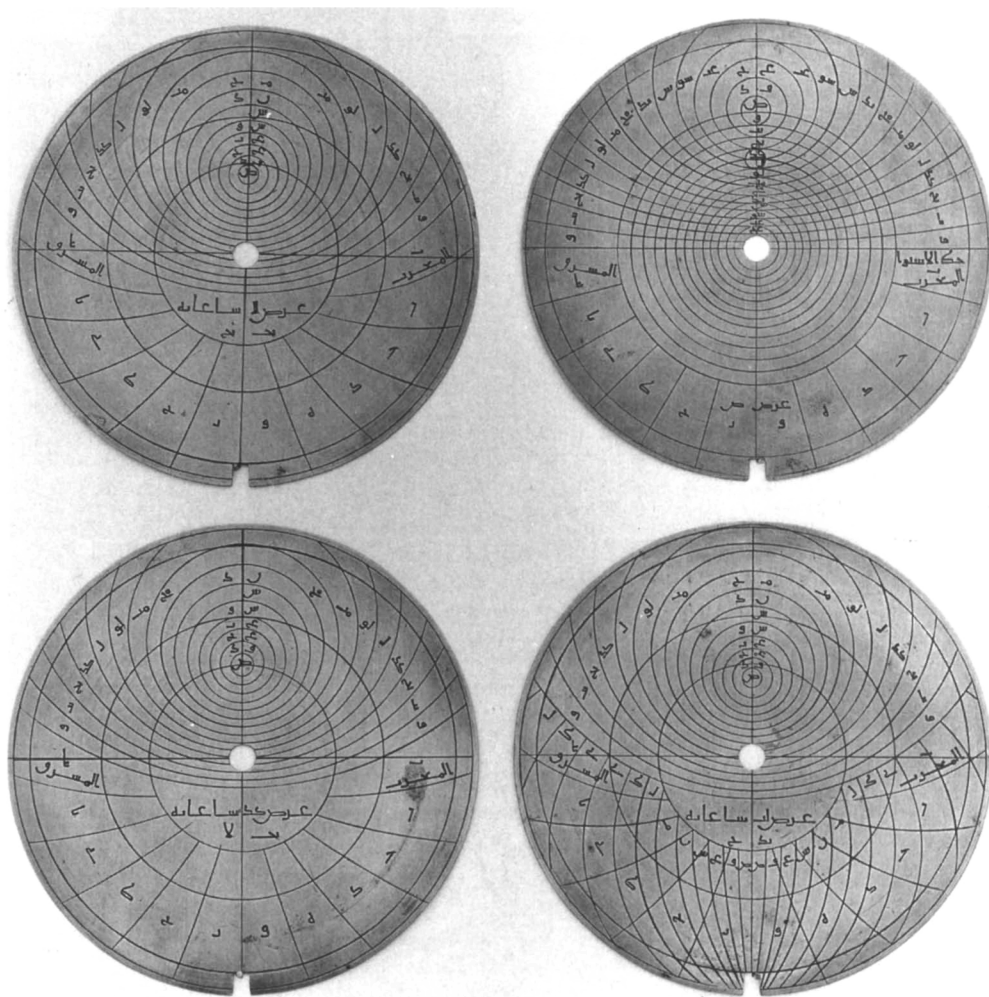


Figure 5 The plates for latitudes 30 and 24 (on the left) and for latitudes 0/90 and 32 (on the right) from an astrolabe made in Isfahan by Muhammad al-Isfahani in 1102/03 (#122). Additional markings on specific plates, such as the azimuth circles here on the plate for 32, are often an indication of the place of construction of an astrolabe. [Photo courtesy of the Istituto e Museo di Storia della Scienza, Florence.]

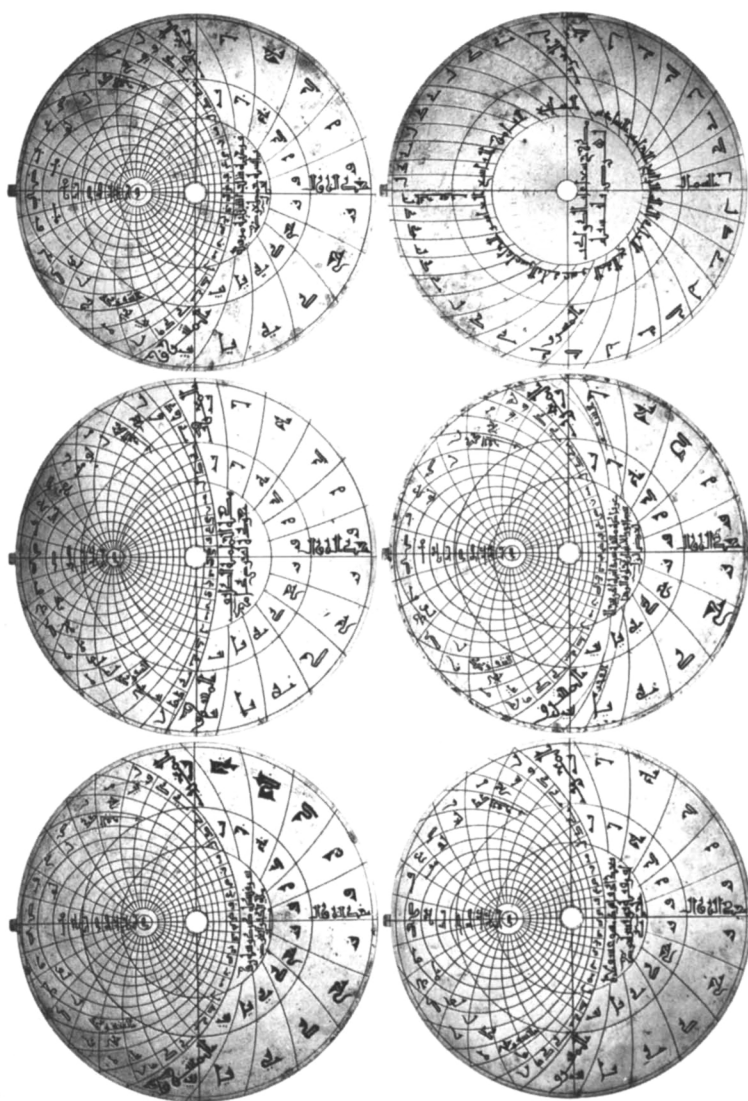


Figure 6 Although the earliest Andalusian astrolabes had plates for the climates, by the 11th century Andalusian astrolabe-plates usually had a series of localities engraved by the side of each latitude. On the plate for latitude 43 (upper left) in the astrolabe of Muhammad al-Sabban dated 1081/82 (#2527), Saragossa, Tortosa and Rome are mentioned. The presence of a special plate for astrological purposes marked for Valencia (lower right), and another one for Saragossa, indicate that the instrument was made in one or other of those cities. [Photo courtesy of the Museum for the History of Science, Oxford.]

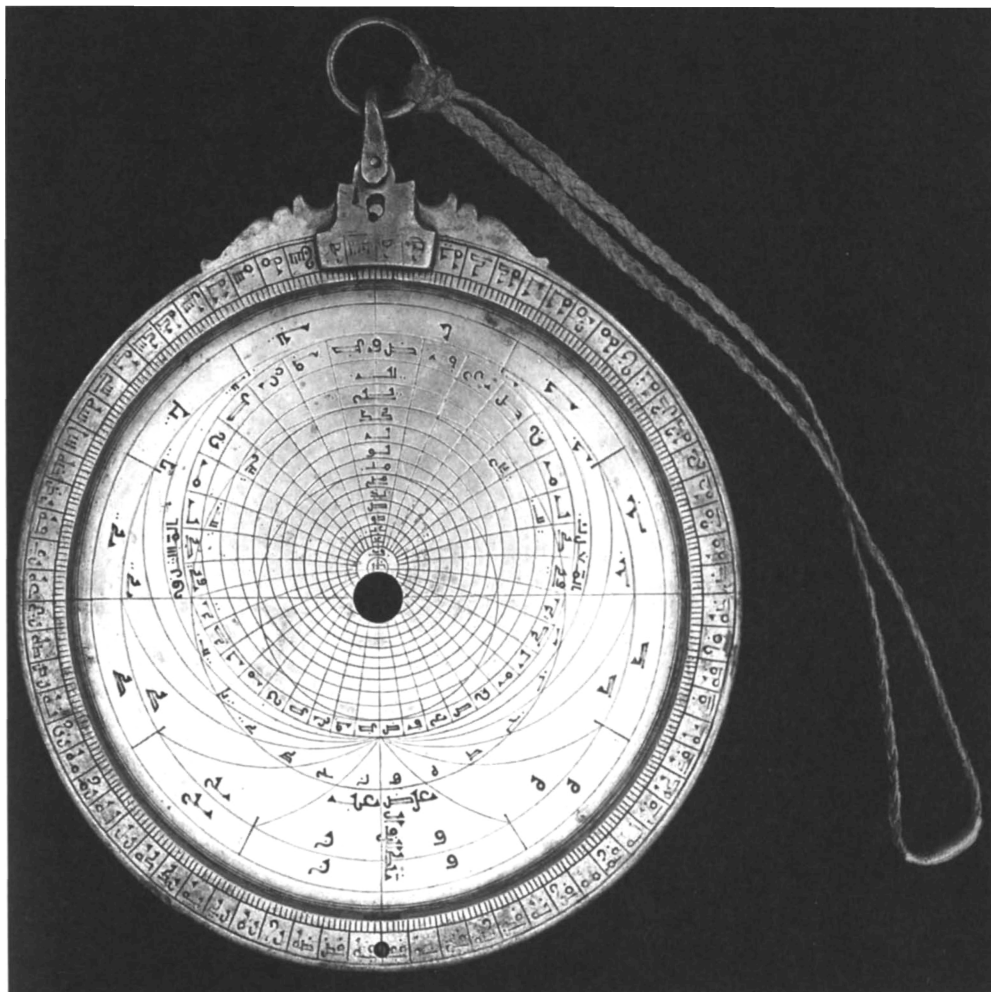


Figure 7 Astrolabic markings for latitude 72 on the mater of an astrolabe by Muhammad ibn al-Saffar and dated 1029/30 (#116). Such markings, like those for latitudes 0 and 90, could only serve pedagogic purposes. [Photo courtesy of the Westdeutsche Bibliothek, Marburg.]

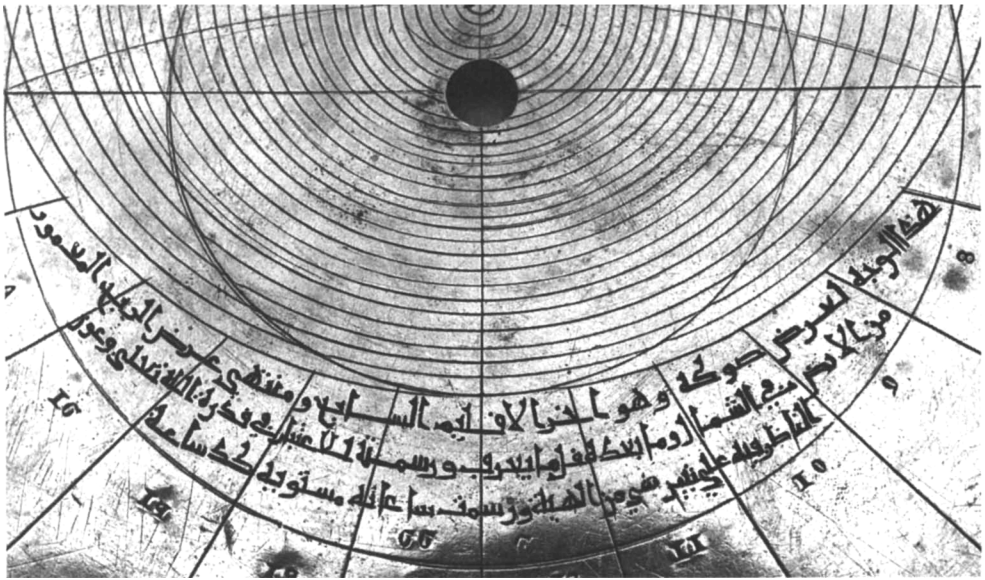


Figure 8 The unusual inscription on markings for latitude 66;25 on the mater of the unsigned astrolabe made in Cordova in 1054/55 (#3622), translated at the beginning of this paper. [Photo by the author, courtesy of the Jagiellonian Museum, Cracow.]

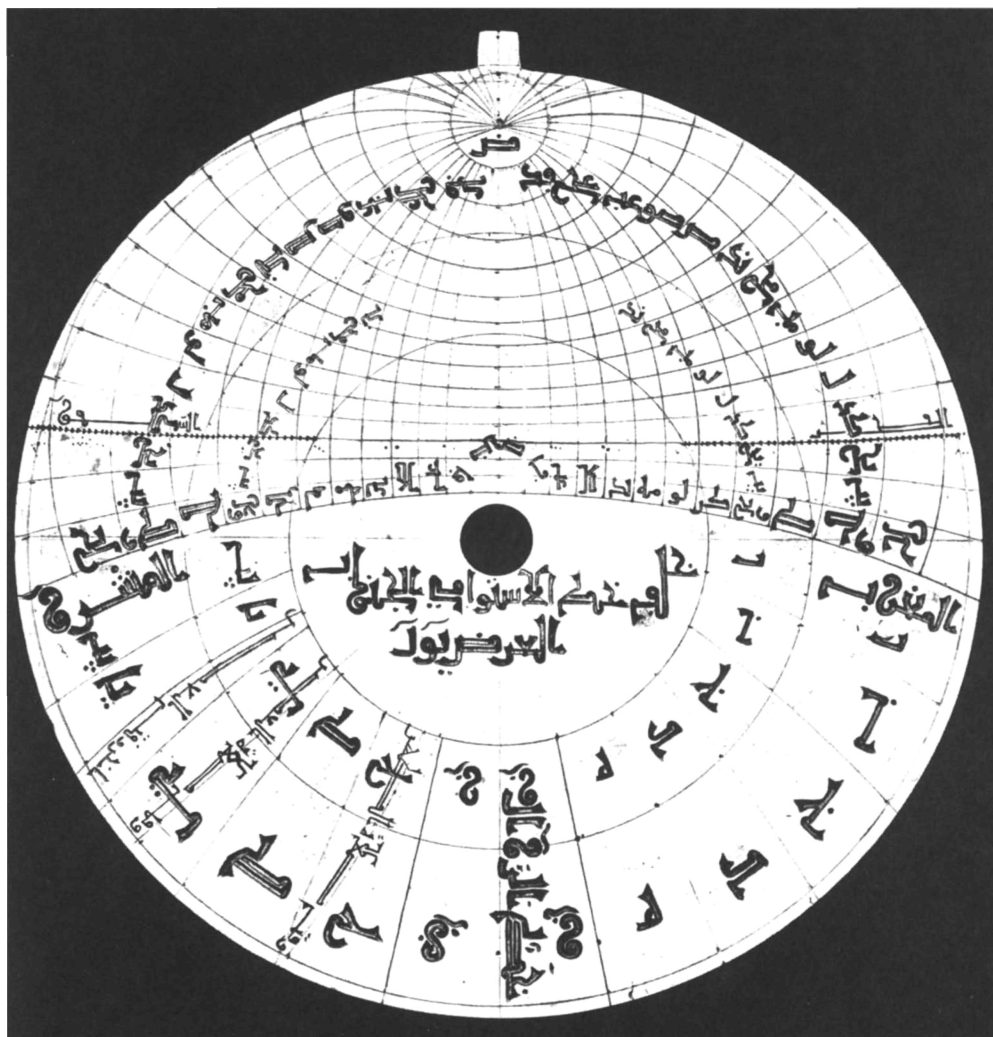


Figure 9 The plate for latitude $16;30^\circ$ south of the equator amidst a set of plates from an 11th-century Andalusian astrolabe (#4040). Quite unique in medieval instrumentation, this plate corresponds to the lower limit of Ptolemy's world-maps. Its existence raises a host of questions about the influence of Ptolemy's *Geography* in early Islamic science and about the Islamic background to medieval European astronomical clocks. [Private collection, photo courtesy of the owner.]

RICHARD LORCH

THE TREATISE ON THE ASTROLABE BY RUDOLF OF BRUGES*

Knowledge of the astrolabe and of stereographic projection was brought to the Latin West in two main stages: the compilation of the *Sententie astrolabii* and related texts¹ in Spain in the late tenth century and the translation, also in Spain, of major works on the subject in the mid-twelfth century. That further material was gained from Arabic sources will be clear below. It has been shown that the *Sententie* is partly a translation of al-Khwārizmī's account of the use of the instrument, but the introductory material appears to be of Latin origin and there is a middle section that appears to have been written in Latin by someone with an astrolabe and perhaps also Arabic texts in front of him.² Several of the other tracts in this group give the impression of being compilations or reworkings. On the basis of these texts other, usually clearer, texts were prepared, e.g. the *De utilitatibus astrolabii* attributed to Gerbert (ca. 945 - 1003)³ and *De mensura astrolabii* by Hermannus Contractus (1013-1054),⁴ who worked in the monastery at Reichenau. Some fragments of a translation of Ptolemy's *Planisphaerium* dating from the *Sententie* era have recently been discovered.⁵

In the mid-twelfth century several important works on, or related to, the astrolabe were translated into Latin. In 1143 Hermann of Carinthia translated Ptolemy's *Planisphaerium* together with some notes by Maslama (d. 1007); further notes by Maslama and his *Extra-Chapter* were translated by two

* For John North, who gave me so freely of his time and expertise in the sixties when I was his student. I am grateful to Paul Kunitzsch and Menso Folkerts for help with several portions of the text, and to Charles Burnett, who sent me a copy of the Naples manuscript.

¹ Edited by Millás in *Assaig d'història de les idees físiques i matemàtiques a la Catalunya medieval*, vol. I, Estudis universitaris Catalans, Sèrie Monogràfica I, Barcelona 1931.

² P. Kunitzsch, 'Al-Khwārizmī as a Source for the *Sententie astrolabii*', *From Deferent to Equant: A Volume of Studies in the History of Science in the Ancient and Medieval Near East in Honor of E. S. Kennedy*, eds. D. A. King and G. Saliba, New York 1987.

³ Edited by Bubnov in *Gerberti opera mathematica*, Berlin 1899, 109-147.

⁴ Edited by Drecker from MS Munich Staatsbibliothek, CLM 14836, in 'Hermannus Contractus Über das Astrolab', *Isis* 16 (1931), 200-219.

⁵ P. Kunitzsch, 'Fragments of Ptolemy's *Planisphaerium* in an early Latin translation', *Centaurus* 36 (1993), 97-101.

different scholars, one of whom also translated Maslama's *Astrolabe Chapters*.⁶

Two translations were made of Ibn alṢaffār's treatise on the uses of the astrolabe: by Plato of Tivoli (active 1133-1145) and by Johannes Hispalensis.⁷ In some manuscripts of Johannes's translation the text is ascribed to Maslama, Ibn al-Ṣaffār's teacher, but this appears to be a mistake.⁸ About this time a short description of the astrolabe with a long account of its uses by one Abraham, probably Abraham b. 'Ezra, was translated, apparently from Hebrew.⁹

Contemporaneous with this translation activity was the composition of several works on the astrolabe in Latin: by Raymond of Marseilles (before 1141)¹⁰, Adelard of Bath (1149-1150)¹¹, Johannes Hispalensis, Rudolf of Bruges (1144 or after), Robert of Chester (1147?, 1150?), the otherwise unknown Arialdus and some anonymous tracts.¹²

⁶ Hermann's translation was edited by Heiberg in *Claudii Ptolemaei opera quae exstant omnia*, vol. II, *Opera astronomica minora*, Leipzig 1907, 225-259. The remaining Maslama pieces are edited in J. Vernet and M. A. Catalá, 'Las obras matematicas de Maslama de Madrid', *Al-Andalus* 30 (1965), 15-45, repr. in J. Vernet, *Estudios sobre historia de la ciencia medieval*, Barcelona 1979, 241-271, and P. Kunitzsch and R. Lorch, 'Maslama's Notes on Ptolemy's Planisphaerium and Related Texts', *Sitzungsberichte der Bayerischen Akademie der Wissenschaften*, phil.-hist. Klasse, Jg. 1994 Heft 2, Munich 1994.

⁷ The Arabic text was edited by Millás in 'Los primeros tratados de astrolabio en la España árabe', *Revista del instituto egipcio de estudios islamicos en Madrid* 3 (1955), 47-76 (Arabic part) and 35-49 (Spanish part). The Johannes translation was also edited by Millás in *Las traducciones orientales en los manuscritos de la Biblioteca Catedral de Toledo*, Madrid 1942, 261-284. The Plato translation is edited in R. Lorch, G. Brey, S. Kirschner and Chr. Schöner, 'Ibn-aṣ-Ṣaffār's Traktat über das Astrolab in der Übersetzung von Plato von Tivoli', *Cosmographica et Geographica. Festschrift für Heribert M. Nobis zum 70. Geburtstag*, eds. B. Fritschner and G. Brey, vol. I, 125-180.

⁸ P. Kunitzsch, 'Glossar der arabischen Fachausdrücke in der mittelalterlichen europäischen Astrolablitteratur', *Nachrichten der Akademie der Wissenschaften in Göttingen*, phil.-hist. Klasse, Jg. 1982 Nr. 11, Göttingen 1983, 480 n. 23.

⁹ Edited in J. Millás Vallicrosa, 'Un nuevo tratado de astrolabio, de R. Abraham ibn 'Ezra', *Al-Andalus* 5 (1940), 1-29. Doubts on the authorship are brought up by R. Levy, 'The Authorship of a Latin Treatise on the Astrolabe', *Speculum* 17 (1942), 566-569, and Millás replies in J. Millás Vallicrosa, 'Sobre un "Tratado de astrolabio" atribuido a R. Abraham ibn 'Ezra', *Sefarad* 4 (1944), 31-88.

¹⁰ The treatise is edited in E. Poulle, 'Le traité de l'astrolabe de Raymond de Marseille', *Studi medievali* 3a Serie, V 2 (1964), 866-900 + 4 plates.

¹¹ Adelard's treatise has been edited by B. Dickey 'Adelard of Bath: An Examination Based on heretofore Unexamined Manuscripts', (unpublished PhD dissertation, Toronto 1982). It is described in E. Poulle, 'Le traité de l'astrolabe d'Adelard de Bath', *Adelard of Bath. An English Scientist and Arabist of the Early Twelfth Century*, ed. C. Burnett, London 1987.

¹² Poulle, 'Raymond' 868 and 'Adelard' 119-120, points to the decade of the 1140's as particularly fruitful. See also E. Poulle, 'L'astrolabe médiéval d'après les manuscrits de la Bibliothèque Nationale', *Bibliothèque de l'École de Chartres* 112 (1954), 81-103, esp. 84. My list of translators and writers on the astrolabe is largely based on these passages and Kunitzsch, 'Glossar', 476-497.

All that we know of Rudolf is contained in the work edited here. He tells us (§10) that he observed the altitude of the Sun in Béziers on 24 April 1144, so that this date is a *terminus post quem* for the composition of the treatise. Again, Rudolf was a pupil of Hermann of Carinthia, as he says in the introduction. Here and when he mentions (§7) Hermann's translation of the *Planisphaerium*, he calls him 'Hermannus Secundus', the first Hermann presumably being Hermannus Contractus.¹³ The preface to the *Planisphaerium* was attributed to him in the editio princeps (Basel 1536), 'Rodulphi Brughensis ad Theodoricum Platonicum in traductionem planisphaerii Claudii Ptolemaei praefatio', but this seems to have no manuscript authority.¹⁴ The Johannes David to whom Rudolf dedicated his treatise is also the dedicatee of Plato of Tivoli's translation of Ibn al-Šaffār. Whoever he was, there is no need to identify him with Avendauth, a Jewish interpreter and philosopher, or with Johannes Hispalensis. A third text, an apocalyptic prophesy for the year 1229 in a manuscript of the second half of the twelfth century, contains the name Joannes David Toletanus as author. M.-Th. d'Alverny says that this Johannes David 'était devenu à cette époque un personnage mythique, sur le plan de Merlin et des Sibylles (...)'.¹⁵ It is perhaps worth remarking that out of the seven witnesses to the dedications to Johannes David, the five manuscripts of the text edited below and the two manuscripts of the Plato translation, only one has 'David' written out¹⁶, the rest having 'dd' with a mark of abbreviation.

The manuscripts

The treatise on the astrolabe by Rudolf of Bruges is known in six manuscripts:

- V: London, British Libr., Cotton, Vespasian A. II, ff. 35rb-37va, 12th-13th c.
- P: Paris, Bibliothèque Nationale, lat. 16652, ff. 24r-28r, first half 13th c.
- N: Naples, Biblioteca Nazionale, VIII C 50, ff. 80r-83v, 12th c.
- R: London, Royal College of Physicians, MS 383, ff. 160r-161v, 13th c.
- D: Oxford, Bodleian Library, Digby 51, ff. 26ra-28ra, 13th c.
- T: Cambridge, Trinity College 1144 (= O 2 40), ff. 126r-128v, end 15th c.

¹³ Hermannus Secundus was the usual form of Hermann's name in the Middle Ages. See Appendix I of Hermann of Carinthia, *De essentiis*, ed. C. Burnett, Leiden 1982, 346.

¹⁴ Heiberg, *Ptolemaei opera*, vol. II, CLXXXVII.

¹⁵ M.-Th. d'Alverny, 'Avendauth?', *Hommenaje a Millás Vallicrosa*, I, Barcelona 1954, 19-43. For Johannes David see pp. 29-32. The quotation is from p. 31. R. Lemay rejects the argument against the identification of Avendauth with Johannes Hispalensis. See Abū Maʿš ar al-Balḥī [Albumasar], *Kitāb al-mudhal(...)*, *Liber introductorii maioris ad scientiam judiciorum astrorum*, vol. 7 [tome III, première partie], *Traduction latine de Hermann de Carinthie (...)*, ed. R. Lemay, Naples 1995, 81-82.

¹⁶ Vatican, Ottobonianus latinus 309, f. 136ra.

VP have construction and use; **DRNT** only construction (explicit: '(...) formulam tenaci memorie commendet', i.e. end of §12). **T**, which leaves out §8, also has no applications, but the text is followed (ff. 128v-129r) by notes on §10.

The list was compiled from Thorndike and Kibre¹⁷ and Carmody's *Critical Bibliography* annotated by Benjamin.¹⁸ Further search in these bibliographies, in Zinner's *Verzeichnis* annotated by himself¹⁹ and in the databank of medieval mathematical manuscripts²⁰ yielded no further manuscripts.²¹

The Cotton manuscript contains texts in many hands, but there is a substantial section in the same hand as the Rudolf text:

27ra-32ra: Abraham ibn 'Ezra, *On the Foundations of Astronomical Tables*. Over half the text is missing at the beginning. The wording is different from the text edited by Millás.²² At the end there is an extra sentence (f. 31vb-32ra), 'Diameter umbre terre est 6^{ta} pars unius (...) et relinquitur diameter umbre'.
32ra-35rb: 'In compositione almanach (...)', mostly on calendrical matters, ending with a table of Persian months.²³
35rb-37va: Rudolf on the astrolabe

¹⁷ L. Thorndike and P. Kibre, *A Catalogue of Incipits of Mediaeval Scientific Writings in Latin*, London 1963, cols 285 and 1119. They refer to C. H. Haskins, *Studies in the History of Mediaeval Science*, Harvard 1927², repr. New York 1960, 56. On this page Haskins transcribes the first paragraph, 'Cum celestium (...) describit', from the Naples manuscript.

¹⁸ F. J. Carmody, *Arabic Astronomical and Astrological Sciences in Latin Translation: A Critical Bibliography*, Berkeley 1956. The copy used, in the Inst. f. Gesch. d. Wiss., Munich, was photocopied (by kind permission of Mrs. Nan Hahn) from the one annotated in manuscript by F. S. Benjamin.

¹⁹ E. Zinner, *Verzeichnis der astronomischen Handschriften des deutschen Kulturgebiets*, Munich 1925, photocopy of the annotated copy in his *Nachlaß* in Frankfurt University.

²⁰ The Databank is in the Institut für Geschichte der Naturwissenschaften, University of Munich.

²¹ Each word of the *incipit* of the section on the use of the instrument, 'perfecta astrolabii fabrica (...) Ac primum(...)' (V 37rb) was searched in Thorndike and Kibre. 'celestium', 'diversam', 'instrumenti', 'postica', 'perfecta' and 'fabri' were searched in the data-base under 'incipit' and 'second incipit'.

²² *El libro de los fundamentos de las Tablas astronómicas de R. Abraham ibn 'Ezra*, ed. J. M. Millás Vallicrosa, Madrid 1947. For the differences of the Cotton manuscript from the printed text we may take the first few lines as a specimen: '[ra]tionem habet ad diametrum; ut si graduum 30 algeib queris, que est ZK, protrahatur linea ZK ad arcum GD cadatque super punctum B; et quia KZ et AB sunt equidistantes super BD, quando protrahitur ZK in directum ut occurrat circumferentie abscondit ab arcu lineam LD equalem arcui DZ.' Here Millás has (p. 131, lines 11-17), '(...) qua proportione se habet ad dyametrum, (...) si querimus ergo [text: 'esgo'] algeib 30 graduum, que est zk, protrahamus columpnam zk, ad arcum cd, cadat super punctum l, et quia ah, zk, sunt due columpne super db equidistantes, quando protraximus columpnam zk in directum, donec occurrerit circumferentie, abscondit de arcu cd, ld, equalem arcui dz, (...)'.
²³ This table appears elsewhere. See, e.g., Suter's Tab 2a in his edition of al-Khwārizmī's tables, *Die astronomischen Tafeln des Muḥammed ibn Mūsā al-Khwārizmī in der Bearbeitung von Maslama ibn Almed al-Madjrīfī und der lateinischen Übersetzung des Athelhard von Bath*, auf Grund der Vorarbeiten von A. Björnbo und R. Besthorn, ed. H. Suter, Copenhagen 1914, 111; and *The Astronomical Tables of al-Khwārizmī*, transl. O. Neugebauer, Copenhagen 1962, 136.

37va-40vb: Abraham on the astrolabe [see above]

P begins with a collection of texts on instruments:

2r-6v: text on the astrolabe attributed on the flyleaf to Johannes Hispalensis.²⁴

7r-9v: William of England on the saphea of al-Zarqāllu

11r-14v: Hermannus Contractus on the astrolabe [see above]

14v(line 13)-21v: 'de utilitatibus astrolabii', chapter-headings and text of the work on the astrolabe attributed to Gerbert [see above]

21v-24r: Hermannus Contractus, *Horologium viatorum*

24r-28r: Rudolf on the astrolabe

28r-37v: Atrialdus, 'de compositione astrolabii' [see above]

The rest of the codex is in another hand. The manuscript was once in the library of Richard de Fournival and was described in his *Biblionomia*, which was written 'vers 1250'.²⁵

Apart from our text **N** contains a translation by Hermann and one of his own works²⁶:

1r-56v: Abu Maʿshar, *Introductorium maius*

58r-80r: *De essentiis*

80r-83v: Rudolf on the astrolabe

Lemay considers that the manuscript was written by Rudolf himself or a scribe working for him. If this is so, somebody else must have drawn the diagrams, for there is a serious omission in the last. The drawing was evidently done after the text, since they sometimes interfere with one another.

R is fully described by N. R. Ker.²⁷ It contains no other astrolabe material.

D is fully described in the introduction to the edition of Plato of Tivoli's translation of Ibn al-Ṣaffār.²⁸ Besides this work, which directly follows Rudolf on the astrolabe, it also contains Hermannus Contractus's *De mensura astrolabii*, *De utilitatibus astrolabii* and *Horologium viatorum* and also the treatise ascribed to Gerbert.

Codex **T** is in one hand, partly Latin, partly English, on various subjects. Our text is the only one on the astrolabe. The name Willelmus

²⁴ The list begins, '1° planisperium ptolomei, 2° et compositiones astrolabii iohannis hispalensis, 3° et opus astrolabii secundum alzerkel, (...)'.
²⁵ A. Birkenmajer, 'La bibliothèque de Richard de Fournival, poète et érudit français du début du XIII^e siècle, et son sort ultérieur', *Studia Copernicana* I (1970), 117-215, this on pp. 119 and 172-174.

²⁶ The codex is described in detail by C. Burnett, *Hermann of Carinthia*, 83-85 and Lemay, *Liber introductorii*, 78-93. Burnett dates it to the twelfth century and Lemay (p. 78) to the middle of the twelfth century.

²⁷ N. R. Ker, *Medieval Manuscripts in British Libraries* I, London, Oxford 1969, 211-212.

²⁸ Lorch et al., 'Ibn-aṣ-Ṣaffār', 134-136. [note 29 and following on p. 79 ff.—Eds.]

Womynd(h)am occurs frequently and is apparently that of the scribe; dates cited are 1494, 1492 and 1482. In the Rudolf text §8 and §13 are not present. Since the manuscript is late and its deviations from the main text—mostly word-order, the substitution of *et* for *atque* and similar, trivial slips like *circulus* for *circulis* etc.—its readings have not been recorded.

In the edition the orthography of **V** has been followed in cases of doubt. The numbers of the paragraphs have been added.

The text

Cum celestium sperarum diversam positionem stellarum diversos ortus diversosque occasus mundo inferiori ministrare manifestum sit¹ huiusque varietatis descriptio ut in plano representetur² sit possibile, prout ptolomeo eiusque sequaci mezlem qui dictus est Aoukakechita³ visum est, pro posse suo huius instrumenti formulam⁴ dilectissimo domino suo Iohanni David⁵ Rodolfus⁶ brugensis Hermanni secundi discipulus⁷ describit.

<1> Primum igitur huius instrumenti est postica, quam quidam matrem dicunt, eo quod infra limbum eius cetera tabule uti filii in utero matris contineantur. Que perpendiculari linea a summo⁸, ubi⁹ ab incatenatis armillis suspenditur, per centrum eiusdem¹⁰ descendente¹¹ tota¹² in duo equa dividatur. Deinde fixo circini pedum altero in eodem centro circinetur circulus in extremitate eiusdem tabule qui linea plana in duo equa sit divisus, in¹³ superius¹⁴ scilicet emispermium et in¹⁵ inferius¹⁶, hac cautela ut he due linee, perpendicularis scilicet et plana¹⁷, totum circulum quatuor equis partibus dividentes¹⁸ sese super centrum circuli medio intersecent. Quo facto circinentur infra hunc alii III circuli pro capacitate graduum intervallorum et signorum ab¹⁹ invicem distantes. Facta itaque circulorum quaterna divisione subdividatur unusquisque quadrans in tria, que collocationi signorum XII²⁰

¹ manifestum sit] sit manifestum **P**

² representetur] representur **D**

³ Aoukakechita] aloukakechita **PN**, acucakathita **R**, aloucaiechita **D**

⁴ formulam] dilectus *add.* **P**

⁵ David] dd **VND**, dd' **PR**

⁶ Rodolfus] Rodulfus **PND**

⁷ discipulus] discipulo **P**

⁸ a summo] assumo **D**

⁹ ubi] si **P**

¹⁰ eiusdem] eius **R**

¹¹ descendente] descendens **VPD**

¹² tota] toto **R**

¹³ in] *om.* **P**

¹⁴ superius] inferius **N**

¹⁵ in] *om.* **R**

¹⁶ in superius (...) inferius] *om.* **D**

¹⁷ scilicet et plana] et plana scilicet **D**

¹⁸ dividentes] dividens **P**

¹⁹ ab] ad **R**

²⁰ collocationi signorum XII] signorum XIII collocationi **D**

distribuimus, quorum XII unumquodque iterum in VI intervalla quinos gradus complectentia sit divisum eritque totus circuitus in CCCLX partes hac ratione divisus.

<2> Ordinatis signorum circulis nunc ad ordinationem circularum mensium transeamus. Cum enim absis²¹ solis a XVIII gradu geminorum²² non excedat ibique duobus gradibus²³ et fere²⁴ dimidio centrum excentris circuli²⁵ a recti²⁶ circuli²⁷ centro elevetur, eadem ratione a centro suprascriptorum circularum centrum circularum mensium elevetur necesse est. Posito²⁸ ergo circini pedum altero in medio²⁹ spatii quinos gradus complectentis in maximo circulo, altero in fine eiusdem spatii³⁰ posito ita ut duos gradus et dimidium³¹ circini pedes includant, postque³² eiusdem spatii supra centrum circularum supradictorum³³ circulus quamvis minime quantitatis circinetur. Deinde regula a³⁴ XVIII^o gradu sagittarii ad XVIII geminorum perducta³⁵ ubi linea a centro versus geminos minimum circulum tetigerit, ibi unus³⁶ circini pedum fixus alter³⁷ versus geminos eiectus³⁸, circulum quanto maiorem poteris³⁹ circumduces⁴⁰, tamen minimum signorum circulum ne contingat caveas. Sicque excentrem circulum solis invenies. Infra quem alios tres, prout ratio postulat, supra centrum excentris circuli circumferes⁴¹. Quorum divisio talis est: in primis⁴² ergo⁴³ totius inferioris emispherii duo arcus extremi in VI equas⁴⁴ partes dividantur, quarum unaqueque⁴⁵ in VI intervalla subdivisa⁴⁶, eorum unumquodque iterum in V subdividatur sicque in inferioris hemispherii arcus CLXXX dies ordinabis. Subtracto deinde a fine superioris hemispherii⁴⁷ arcus v dierum spatio reliquum in VI iterum⁴⁸ seiungatur⁴⁹ partes, e⁵⁰ quibus unaqueque in sexies quinis subdistincta diebus.

²¹ absis] ab hiis R

²² geminorum] *om.* P

²³ gradibus] *om.* N

²⁴ fere] *om.* D

²⁵ circuli] circulis D

²⁶ recti] recto N

²⁷ a recti circuli] *om.* P

²⁸ Posito] posita D

²⁹ medio] unius *add.* N

³⁰ spatii] supra centrum circularum *add. et del.* R

³¹ dimidium] *om.* N

³² postque] positique R

³³ circularum supradictorum] supradictorum circularum ND

³⁴ a] ab P

³⁵ perducta] producta D

³⁶ unus] unius V, uno R

³⁷ fixus alter] fixo altero R

³⁸ eiectus] ecentro VR

³⁹ maiorem poteris] maiore positus R

⁴⁰ circumduces] circumducere P

⁴¹ circuli circumferes] circumferes circuli PR

⁴² primis] primo N

⁴³ ergo] igitur ND

⁴⁴ equas] equa N

⁴⁵ unaqueque] unaquaque V

⁴⁶ subdivisa] equorum *add. et del.* P

⁴⁷ hemispherii] *om.* D

⁴⁸ in VI iterum] iterum VI in R

⁴⁹ seiungatur] seiungantur R

⁵⁰ e] et R

Reperies in toto arcu superioris hemisperii, adiecto v dierum⁵¹ spatio quod⁵² superius ab eodem arcu subtraxeras, CLXXXV dies. Sicque in toto circuitu CCCLXV dies consumabis.⁵³

<3> His circulis ita inventis nunc signorum mensium succedit ordinatio. Circulorum itaque signorum et mensium⁵⁴ duabus lineis quaterna⁵⁵ divisione facta perpendiculari scilicet et plana, ut levior supradictorum fiat⁵⁶ ordinatio, linearum descriptiones subiungamus. Illa vero que a centro primo ad sinistram postice partem deducitur orientalis dicitur, ab eodem centro ad dextram occidentalis; que ab eodem centro⁵⁷ versus armillam consurgit meridionalis, sub centro ad imum descendens septentrionalis.⁵⁸ Cum enim⁵⁹ in circulo signorum primo loco arietem⁶⁰ ponimus⁶¹, nequaquam⁶² et mensem illum in quo sol primum arietis gradum perlustrat⁶³, primo loco in ordine⁶⁴ mensium poni dignum⁶⁵ iudicamus. Igitur ab occidentali linea sursum versus⁶⁶ meridiem in circulo⁶⁷ signorum⁶⁸ arietem⁶⁹ in spacio XXX graduum collocamus; ab eodem puncto eius lineae⁷⁰, a quo⁷¹ aries sumit initium, in circulo mensium⁷² martio mense sursum versus meridiem dies XVI⁷³ deputamus. Deinde post arietem versus⁷⁴ meridiem taurum et geminos ordinamus; post meridiem vero cancrum leonem et virginem usque⁷⁵ ad orientalem⁷⁶ lineam depingimus; ab⁷⁷ orientali linea ad imum libra scorpius et⁷⁸ sagittarius inscribantur; ab imo iterum ad lineam occidentalem capricornus aquarius pisces⁷⁹ ordinentur. Post martium vero in circulis mensium sursum iterum versus meridiem aprili XXX dies annumerabis,

⁵¹ dierum] derum N

⁵² quod] quam VPN, quem D

⁵³ consumabis] deputabis D

⁵⁴ succedit (...) mensium] *om.* R

⁵⁵ quaterna duabus lineis D

⁵⁶ fiat] *om.* P

⁵⁷ centro] *om.* R

⁵⁸ septentrionalis] medie noctis linea nuncupatur que et septentrionalis vocatur D

⁵⁹ enim] *om.* D

⁶⁰ primo loco arietem] arietem primo loco R

⁶¹ ponimus] ponamus D

⁶² nequaquam] necnon D

⁶³ perlustrat] *om.* D

⁶⁴ ordine] ordinationem D

⁶⁵ dignum] minus dignum ND, indignum R

⁶⁶ versus] usque D

⁶⁷ circulo] circulis N

⁶⁸ signorum] progredientes *add.* N

⁶⁹ arietem] ariete P

⁷⁰ eius lineae] lineae eiusdem N

⁷¹ quo] qua R

⁷² mensium] mencium P

⁷³ dies XVI] XIII dies D

⁷⁴ versus] usque D

⁷⁵ usque] *om.* D

⁷⁶ orientalem] orientem talem P

⁷⁷ ab] imo iterum ad lineam *add. et del.* P

⁷⁸ et] *om.* R

⁷⁹ pisces] et piscem P, et pisces N

maio⁸⁰ XXXI; item⁸¹ a meridie ad oriens⁸² iunio 30⁸³, iulio XXXI, augusto XXXI; sicque ab oriente ad imum septembri XXX, octobri XXXI, novembri⁸⁴ XXX; postque ab imo sursum versus lineam occidentalem decembri XXXI, ianuario XXXI, februario XXVIII; ac deinde martio qui superius relictus fuerant xv⁸⁵ addimus.

<4> His ita constitutis nunc quadrati mensuram, in quo non minima geometrie peritia⁸⁶ physica indago⁸⁷ comperta est, investigemus. Sed ut huius descriptionis competens fiat instructio, primo supra centrum primum infra omnes alios circulos Π^{os} circulos minime⁸⁸ ab invicem distantes circumducimus; indeque unius circuli unumquemque quadrantem in duo⁸⁹ equa⁹⁰ partimur. Postque inter duo puncta inferioris hemisperii lineam rectam continuamus⁹¹; inter duo iterum⁹² puncta⁹³ superioris hemisperii aliam lineam⁹⁴ huic oppositam deducimus: eruntque hee due⁹⁵ linee sibi invicem equidistantes. Deinde a termino dextro⁹⁶ linee superioris in dextrum terminum linee inferioris tertiam lineam protrahimus; huic oppositam quartam eadem ratione constituimus. Quibus ita constitutis habebis quadratum⁹⁷ equilaterum rectiangulum⁹⁸; huius vero quarta pars cum ad geometricales mensuras sufficere queat, illam que leoni opponitur⁹⁹ eligimus. Constitutis igitur¹⁰⁰ infra huius quadrati latera¹⁰¹ huius Π^{or} lineis sibi invicem tetragonaliter concurrentibus omnes in VI equas dividantur¹⁰² partes¹⁰³, quarum unaqueque in duo sit subdivisa, hac institutione ut erectum latus eiusdem quadrati in XII planumque in totidem sit divisum.

<5> Hec a nobis de postica quanto compendiosius potuimus digesta sunt. Sed ut tam inperitis quam studiose indagentibus facilius pateant in spera subiecta descripta sufficiant. Super quam est alhaidada, id est linea circumvertibilis, quam¹⁰⁴ quidam

⁸⁰ maio] madio D

⁸¹ item] iterum D

⁸² oriens] *corr. ex orientis P, orientem R*

⁸³ iunio 30] *om. VPN*

⁸⁴ novembri] *corr. ex novembris D*

⁸⁵ xv] XXVII *corr. ex XVII D*

⁸⁶ minima geometrie peritia] minimam geometrie periciam VPN D

⁸⁷ indago] indagatio R

⁸⁸ minime] supra D

⁸⁹ in duo] supra N

⁹⁰ equa] *om. N*

⁹¹ continuamus] contineamus N

⁹² iterum] *om. D*

⁹³ puncta] vero *add. D*

⁹⁴ aliam lineam] *om. N*

⁹⁵ due] du N

⁹⁶ dextro] dextre VPN R

⁹⁷ quadratum] quadrant' P

⁹⁸ rectiangulum] rectangulum R

⁹⁹ opponitur] opponit PN

¹⁰⁰ igitur] *om. P, itaque N*

¹⁰¹ latera] lateribus PND; huius *add. V*

¹⁰² dividantur] dividant D

¹⁰³ dividantur partes] partes dividantur R

¹⁰⁴ quam] *om. D*

radium¹⁰⁵ vocant¹⁰⁶, que ad singulas notas dierum ducta¹⁰⁷ per presentem diem mensis cuiuslibet¹⁰⁸ nobis notum, hinc non mota regula gradum solis, in quocumque signorum fuerit, invenire possimus.¹⁰⁹ Converso quoque modo per gradum solis nobis notum versa ratione diem presentem presentis mensis invenire valeamus. Super quam due pinne¹¹⁰ ortogonaliter erecte scilicet in extremitate eius consoliduntur¹¹¹, duobus in locis in directo perforate linee¹¹² ut strictioribus duobus ut sese respiciunt altitudo solis, amplioribus vero stellarum altitudo, dinoscitur.

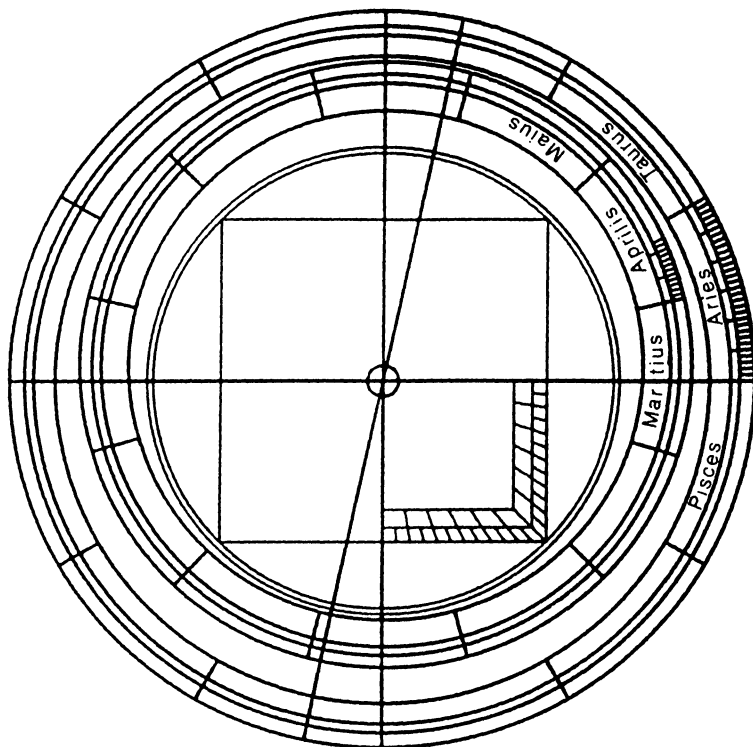


Figure 1

¹⁰⁵ radium] radum R

¹⁰⁶ vocant] appellant D

¹⁰⁷ ducta] per presentem *add. et del. D*

¹⁰⁸ mensis cuiuslibet] cuiuslibet mensis D

¹⁰⁹ possimus] possumus R

¹¹⁰ pinne] pinnee VP

¹¹¹ eius consoliduntur] consoliduntur eius N consoliduntur] consoliduntur PR

¹¹² perforate linee] *corr. ex linee perforate V, linee perforate P*

<6> Sequitur deinde de inventione trium circulorum descriptio, quorum medius vicem et nomen equinoctialis circuli optinet; cuius alterutra¹¹³ ex parte ad utrumque circulum maxima solis perpenditur declinatio.¹¹⁴ Est enim maxima solis declinatio prout ptolomeo placet XXIII graduum et LV punctorum; quidam vero¹¹⁵ XXIII¹¹⁶ et XXXV punctorum metiuntur. Cum vero¹¹⁷ parum interest, ptolomei sententiam, prout maioris apud astrologos habeatur¹¹⁸ auctoritatis, in medium proponamus. Formetur itaque tabula ad quantitatem¹¹⁹ planicie infra limbum¹²⁰ contente; in qua super¹²¹ centrum *A* circumducatur circulus¹²² trium circulorum maximus ita ne extrema tabule labra contingat, qui III^{or} punctis duas lineas sese supra¹²³ centrum *A* intersecantes terminantibus sit divisus. Et sit *B* punctum orientale, *C* huic oppositum occidentale, *D* superius punctum meridionale¹²⁴, *E*¹²⁵ inferius septentrionale. Deinde arcus *DB* tribus intersticiis sit divisus, quorum *B* affinius—vel *D* si magis placuerit—in quinquepartita¹²⁶ intervalla sit divisum. Postque a *D* versus *B* in fine spaciorem IIII notam *F* inprime, deinde apposita regula super puncta *C* et *F* ubi linea meridionalis a regula tangitur *G* notam pone, sicque super¹²⁷ centrum *A* spacio vero *G* circulum equinoctialem *GHIK* circumferens.¹²⁸ Eadem¹²⁹ vero ratione et minimum circulum *LMNO* per equinoctialem invenies. Quod ut facilius pateat figura subiecta¹³⁰ demonstrat.¹³¹

¹¹³ alterutra] alternatio **P**

¹¹⁴ perpenditur declinatio] declinatio perpenditur **D**

¹¹⁵ vero] *om.* **D**

¹¹⁶ XXIII] graduum *add.* **D**

¹¹⁷ vero] enim **D**

¹¹⁸ habeatur] habebitur **R**

¹¹⁹ ad quantitatem] aliquantitatem **D**

¹²⁰ limbum] libum **R**

¹²¹ super] supra **ND**

¹²² circulus] circulis **P**

¹²³ supra] supra **ND**

¹²⁴ meridionale] est *add.* **R**

¹²⁵ *E*] *F* **N**

¹²⁶ quinquepartita] quinquipartita **N**

¹²⁷ super] supra **ND**

¹²⁸ circumferens] circumferes **N**

¹²⁹ Eadem] modo *add. et del.* **N**

¹³⁰ subiecta] subscripta **R**

¹³¹ Quod ut (...) demonstrat] Cuius exempli gratia figura subscribatur **D**

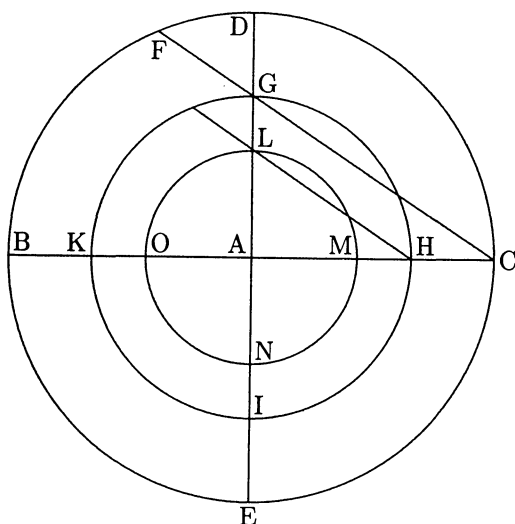


Figure 2

<7> Tribus circulis ita inventis sequitur hankabuth descriptio, quod quidam volvellum quidam rete¹³² nuncupant.¹³³ Fixo igitur circini pedum altero ubilibet in linea septentrionali ita ut alter pedum utrimque¹³⁴ pari distantia *E* et *L* puncta occupet, postque eodem spacio declivis circulus¹³⁵, qui et via solis dictus est, circumferatur hac cautela ut medius medium¹³⁶ equinoctialem ad puncta *H* et *K*¹³⁷ intersecet. Infra quem¹³⁸ alii¹³⁹ tres circuli conformentur. Qui omnes III^{or} secundum partitionem maximi circuli et¹⁴⁰ in signa et¹⁴¹ intervalla sint divisi.¹⁴² facta itaque maximi circuli divisione in XII scilicet signa postque in LXXII intervalla ponatur regula super¹⁴³ centrum trium circulorum, ac inde non mota ad singulas maximi circuli divisiones posita ubi viam solis tetigerit zodiacum linea secabit, quousque totum zodiacum in XII signa et eadem in LXXII intervalla subdiviseris. Que nunc contractiora nunc longiora, prout ratio declivis circuli postulat, ordinantur; nam si

¹³² rete] recte P, corr. ex recte D

¹³³ nuncupant] nuncupatur P

¹³⁴ utrimque] supra R

¹³⁵ circulus] circulis VP

¹³⁶ medius medium] om. ND

¹³⁷ medius medium add. ND

¹³⁸ quem] quam PN

¹³⁹ alii] om. VR

¹⁴⁰ et] om. D

¹⁴¹ et] om. N

¹⁴² divisi] indivisi N

¹⁴³ super] supra ND

declivis circuli distancie¹⁴⁴ a recto rationem cognoveris, inequalitatem¹⁴⁵ duorum hemisperiorum declivis circuli non miraberis. Sed qui huius inequalitatis rationem¹⁴⁶ nosse desiderat, planisperium ptolomei ab¹⁴⁷ hermano¹⁴⁸ secundo translatus legat. Sed ne suprascripta¹⁴⁹ lectoris animum turbent¹⁵⁰, in huius volvelli descriptione depicta clarescant.¹⁵¹

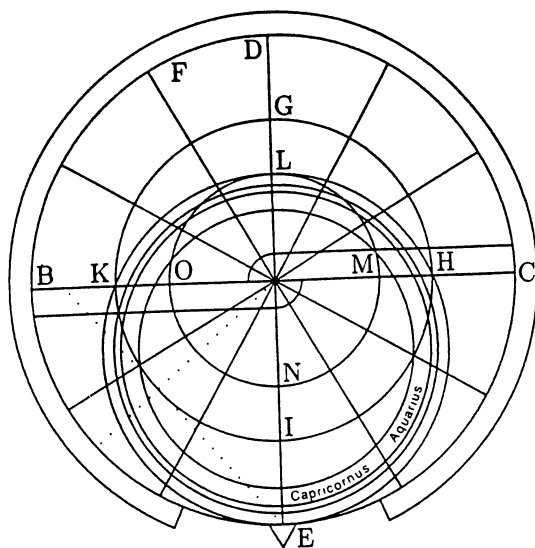


Figure 3

<8> Nunc quarundam stellarum in hancabuth claviculos ordinare convenit, quarum¹⁵² acuminibus in metiendis arcubus noctium accipiendisque horis nocturnalibus firmandisque domiciliis vice stellarum potimur.¹⁵³ Sed ne nimia prolixitas orationis lectori moram¹⁵⁴ faciat, earum nomina longitudes latitudes—etiam¹⁵⁵ que septentrionales¹⁵⁶ que australes sint—prout alcaurismus¹⁵⁷ ceterique

¹⁴⁴ declivis circuli distancie] distancie declivis circuli N

¹⁴⁵ inequalitatem] inequalitate D

¹⁴⁶ rationem] om. N

¹⁴⁷ ab] om. R, a N

¹⁴⁸ hermano] h'. in anno D

¹⁴⁹ suprascripta] om. D

¹⁵⁰ animum turbent] animus D

¹⁵¹ depicta clarescant] turbetur que diximus depicta pateant in figura D

¹⁵² quarum] quorum ND

¹⁵³ potimur] utimur D

¹⁵⁴ moram] mora V

¹⁵⁵ etiam] et R, om. D

¹⁵⁶ septentrionales] et add. D

¹⁵⁷ alcaurismus] alcharismus PN, alhaarizmus D

philosophi¹⁵⁸ docent, in figura in proximo descripta¹⁵⁹ patefacimus¹⁶⁰. Exempli tamen gratia, ut ad hoc facilius pateat aditus, unam¹⁶¹ ex¹⁶² primo collocabimus Munirmenelfeca, que apud nostrates¹⁶³ splendens dicitur, septentrionalis in XI^o gradu scorpii¹⁶⁴ posita¹⁶⁵ cuius¹⁶⁶ latitudo XLIX graduum. Eius locus sic reperitur¹⁶⁷: regula super XI^o¹⁶⁸ gradum scorpii¹⁶⁹ et super centrum trium¹⁷⁰ circulorum posita inter utrumque terminus lineam¹⁷¹ continuabis¹⁷²; sicque¹⁷³ longitudine eius inventa utraque ex parte XI^o¹⁷⁴ gradus scorpii XLIX gradus computabis; in quorum¹⁷⁵ terminis punctis impressis, hisdem regula superponatur et ubi lineam longitudinis tetigerit ibi locum eiusdem stelle esse cognoscas. Cui denticulum in cuius sumitate stella¹⁷⁶ insideat, ut¹⁷⁷ in prefata figura ostenditur, adaptabis. Hac itaque collocata constat ut¹⁷⁸ australem exempli gratia collocemus: Rigilalgebar¹⁷⁹, id est pes orionis, in III^o¹⁸⁰ geminorum posita, cuius latitudo australis LVII graduum, ita eius locum invenire¹⁸¹ convenit. Posita itaque regula super¹⁸² centrum predictum et super¹⁸³ tertium geminorum, per que ad¹⁸⁵ circumferentiam maximi circuli linea recta protrahatur. Ibique puncto quolibet inpresso utrimque LVII^o¹⁸⁶ gradus in eodem maximo circulo duobus punctis terminabis. Quibus regula superposita ubi¹⁸⁷ lineam¹⁸⁸ a centro circuli per III geminorum ad circumferentiam eductam tetigerit locum pedis orionis notabis cuius denticuli radicem in equinoctiali¹⁸⁹ circulo figes. Hac itaque ratione

¹⁵⁸ philosophi] *om.* D

¹⁵⁹ descripta] *corr. ex scripta* P

¹⁶⁰ patefacimus] patefaciamus R; in (...) patefacimus] subiecta describemus D

¹⁶¹ unam] duas D

¹⁶² ex] his *add.* ND

¹⁶³ nostrates] nos D

¹⁶⁴ scorpii] scorpionis D

¹⁶⁵ posita] posito D

¹⁶⁶ cuius] um *add. et del.* P

¹⁶⁷ reperitur] invenitur D

¹⁶⁸ XI] XII P, xim N

¹⁶⁹ scorpii] scorpionis D

¹⁷⁰ trium] *om.* N

¹⁷¹ lineam] rectam *add.* D

¹⁷² continuabis] continuabimus D

¹⁷³ sicque] continuabis *add. et del.* P

¹⁷⁴ XI] XII P

¹⁷⁵ quorum] quarum VP

¹⁷⁶ stella] *om.* N

¹⁷⁷ insideat ut] insideatur P; exempli gratia collocemus. Rigil algebar *add. et del.* N

¹⁷⁸ ut] ut et N, et ut D

¹⁷⁹ Rigilalgebar] Ragilhalgebar P

¹⁸⁰ III] tertio P, modo D; gradu in duo xpo gradu et qa (?) punc (?) *add.* P

¹⁸¹ invenire] venire V, reperimus D

¹⁸² convenit] *om.* D

¹⁸³ super] supra ND

¹⁸⁴ super] supra ND

¹⁸⁵ ad] *om.* N

¹⁸⁶ LVII] LVI N

¹⁸⁷ ubi] vero P

¹⁸⁸ lineam] linea VR

¹⁸⁹ equinoctiali] equinoctiale V

ceterarum stellarum fixarum loca reperiuntur quibus tam orientium quam horarum consequeris¹⁹⁰ notitiam. Quarum descriptio¹⁹¹ talis substituitur.¹⁹²
[star table—see below]

<9> Extra maximum vero circulum alium circulum umboni contiguum qui et limbus¹⁹³ dicitur circumscripsimus¹⁹⁴; a quo¹⁹⁵ arcum¹⁹⁶ XXX graduum¹⁹⁷ resecavimus a XV scilicet sagittarii usque ad XV capricorni. In cuius arcus medio denticulus promineat, qui almeri id est¹⁹⁸ limitator et¹⁹⁹ calculator dictus est, ut divisa umbonis circuitione denticulo²⁰⁰ affiniore in CCCLX²⁰¹ gradus remotiori vero in LXXII intervalla, in quibus gradibus et intervallis ut facilius²⁰² fiat computatio, per eundem calculatorem quot gradibus unumquodque signorum in recto²⁰³ circulo secundum diversas regiones oriatur²⁰⁴ particionesque intervallorum almucantarath atque horarum ceteraque huiusmodi comperire poteris.

<10> Cum enim²⁰⁵ latitudinem uniuscuiusque regionis ubique²⁰⁶ terrarum scire volueris, dispositis ut supra in plana spera tribus circulis scilicet recto²⁰⁷ et duobus equidistantibus, super²⁰⁸ quam²⁰⁹ equaliter collocetur alhankabut signis et eorum gradibus insignitum, primo tamen gradu solis cognito²¹⁰, deinde in medio²¹¹ die eiusdem loci in quo fueris in dorso astrolapsus altitudinem solis accipe²¹², qua cera notata²¹³ gradum solis super meridionalem lineam pone²¹⁴, postque totam altitudinem in VI partire; sique²¹⁵ quid²¹⁶ minus VI superfuerit, in superiori parte puncti²¹⁷ quem gradu solis denotavimus²¹⁸ relinque. Ac deinde²¹⁹ linea posita super

¹⁹⁰ consequeris] consequens R

¹⁹¹ descriptio] dispositio DN

¹⁹² substituitur] posicio tabule stellarum fixarum *add.* R

¹⁹³ limbus] lilimbus P

¹⁹⁴ circumscripsimus] conscripsimus P

¹⁹⁵ quo] qua P

¹⁹⁶ arcum] arcus P

¹⁹⁷ graduum] dierum D

¹⁹⁸ id est] *om.* P

¹⁹⁹ et] vel N

²⁰⁰ denticulo] denticuli P

²⁰¹ CCCLX] CCO LX D

²⁰² gradibus et intervallis ut per eum] graduum numerus ut facilius per eum D

²⁰³ recto] raicto P

²⁰⁴ oriatur] oriantur V

²⁰⁵ Cum enim] <C>umque R

²⁰⁶ ubique] ubicumque ND

²⁰⁷ scilicet recto] recto scilicet D

²⁰⁸ super] supra ND

²⁰⁹ quam] *om.* N

²¹⁰ cognito] cognitio P

²¹¹ Deinde in medio] *repet.* R

²¹² accipe] accipit P

²¹³ notata] vocata R

²¹⁴ pone] supra D

²¹⁵ sique] sicque D

²¹⁶ quid] quod D

²¹⁷ parte puncti] puncto D

²¹⁸ denotavimus] in corr. V

²¹⁹ deinde] de N

punctum H^{220} ac inde non²²¹ mota < ... > per divisiones equinoctialis circuli super punctum²²² gradu²²³ solis denotatum supradictas²²⁴ partes altitudinis²²⁵ solis in linea meridionali ordinabis. Verbi gratia: anno domini $M^0C^0XL^0III^{10226}$ biteris in gotia iuxta mare mediterraneum²²⁷ tabulam latitudinis eiusdem regionis fabricare volens—XXIII die aprilis²²⁸ sol²²⁹ quartum tauri gradum occupabat, cuius altitudo LXII erat graduum, qui per VI divisi—X sexquipartita²³⁰ intervalla contulimus. Quibus duo tantum²³¹ gradus superant. Posito itaque²³² gradu solis super lineam meridionalem ibique punctum P ponimus. Deinde totum circulum equinoctialem in LX intervalla subdividimus.²³³ Quo facto regulam super punctum H et²³⁴ super quemlibet²³⁵ punctorum in sinistro quadrante, ita ut quam proxime super²³⁶ notam P^{237} perveniat positam²³⁸, ibique primum punctum primi intervallorum X^{239} que superius ex altitudine solis accepimus²⁴⁰, imprimimus.²⁴¹ Ac deinde regulam superius elevando in linea meridionali secundum intervalla equinoctialis circuli usque ad Q longe extra circulum X intervalla²⁴² ordinamus.²⁴³ Postque iterum regulam sub P < ... > inferius in eadem linea septentrionali pro²⁴⁴ diversis ut supra equinoctialis circuli partitionibus X^{245} intervalla annumeravimus²⁴⁶, in quorum fine punctum R imprimimus.²⁴⁷

Sicque in linea meridionali completis XXX intervallis scilicet inter Q et R punctos²⁴⁸ sequitur de almucantarate lineationibus. Fixo itaque circini pedum altero in medio

²²⁰ H : gradu solis *add. et del.* N

²²¹ non] nunc R

²²² punctum] per *add.* R

²²³ gradu] gradum VPR, *gradd-* D

²²⁴ supradictas] supradictans V

²²⁵ altitudinis] c *add. et del.* V

²²⁶ $M^0C^0XL^0III^{10}$] $M^0C^0XL^0V^0$ P, M.CLX.III D

²²⁷ mediterraneum] terrarum D

²²⁸ die aprilis] *om.* N

²²⁹ sol] solis D

²³⁰ sexquipartita] sesquipartita V

²³¹ duo tantum] tantum duo R

²³² graduum, qui (...) itaque] *om.* P

²³³ subdividimus] subdivisimus VN, distribuimus D

²³⁴ et] si opus fuerit supra VP, *add. in textu* R

²³⁵ quemlibet] quamlibet D

²³⁶ super] supra D

²³⁷ et super (...) P] *om.* N

²³⁸ positam] *om.* D

²³⁹ X] *om.* D

²⁴⁰ accepimus] accipimus VP

²⁴¹ imprimimus] impressimus D

²⁴² intervalla] annum animus in quorum fine punctum R *add. et del.* N

²⁴³ ordinamus] ordinavimus VRD

²⁴⁴ pro] per V

²⁴⁵ X] XX D

²⁴⁶ annumeravimus] annum animus V; Postque iterum (...) annumeravimus] *om.* P

²⁴⁷ imprimimus] denotavimus D

²⁴⁸ punctos] puctos V, punctis ND

almucantarath a superiori hemisperio²⁶⁰ absciderat²⁶¹, scilicet²⁶² *SET* et *HIK*²⁶³ et *YNZ*²⁶⁴ unoquoque²⁶⁵ in XII partibus ponetur²⁶⁶ alter pedum²⁶⁷ circini ubilibet vel²⁶⁸ super²⁶⁹ tabulam vel longe extra ita ut²⁷⁰ alter pedum primas III divisiones, quas in tribus arcubus feceramus, equaliter pertingat et sic primam lineam prime hore deducimus. Hac itaque ratione et ceteras lineas²⁷¹ horarum ordinamus²⁷² circinum nunc contrahendo nunc dilatando ex una parte lineae septentrionalis²⁷³ VI et ex alia totidem collacamus, ut in suprascripta²⁷⁴ *spera*²⁷⁵ patefecimus.

<12> Data igitur diversarum regionum latitudinum inventionem sequitur ut de verticalibus circulis, quos²⁷⁶ quidam azimuth quidam vero cenit capitum²⁷⁷ alii zumpruz²⁷⁸ appellant, quedam subiungamus, qui in usum saracenorum distributi²⁷⁹ ut qua parte orationes²⁸⁰ fundant²⁸¹ per ipsos cognoscant. Nos²⁸² vero brevi²⁸³ industria nostris instrumentis illos inscribimus, ut omni die ubique²⁸⁴ terrarum distantiam²⁸⁵ ortus et occasus luminum a recto circulo per illos comprehendere possimus. Producta itaque linea longe extra circulum in directo lineae septentrionalis, in qua circini pedum²⁸⁶ altero fixo sive infra trium circulorum spatium²⁸⁷ sive²⁸⁸ extra ubilibet ita ut alter pedum²⁸⁹ medium punctum XV orbiculorum, quem etiam²⁹⁰ nota *Z*²⁹¹ designamus, punctaque equinoctialia *H* et *K* simul attingant, quo facto ad mensuram trium spaciolorum circinetur circulus scilicet *AK AZ AH*²⁹² qui a quibusdam

²⁶⁰ hemisperio] *corr. ex emisperio* V

²⁶¹ absciderat] abscidant (?) ND

²⁶² scilicet] *om.* D

²⁶³ *HIK*] *HYK* P, *I* supra P

²⁶⁴ *YNZ*] *YNZZ* N

²⁶⁵ unoquoque] unumquemque ND

²⁶⁶ ponetur] ponatur D

²⁶⁷ pedum] pedu P; primas iii divisiones *add. et del.* N

²⁶⁸ vel] et *VPNR*

²⁶⁹ super] supra D

²⁷⁰ ut] *om.* N; alter pedum (...) ut] *repet. et del.* D

²⁷¹ lineas] *om.* N

²⁷² ordinamus] lineas *add.* N

²⁷³ lineae septentrionalis] septentrionalis lineae R

²⁷⁴ suprascripta] *corr. ex supradicta* R

²⁷⁵ *spera*] *om.* P

²⁷⁶ quos] quis V, quas P

²⁷⁷ cenit capitum] cenitapicum R, cempt capitum D

²⁷⁸ zumpruz] zumpruz D

²⁷⁹ distributi] distribui VR

²⁸⁰ orationes] orationem D

²⁸¹ fundant] *om.* D

²⁸² Nos] Hos (?) VP

²⁸³ brevi] hac PND

²⁸⁴ ubique] ubicumque ND

²⁸⁵ distantiam] distantia D

²⁸⁶ pedum] medium punctum *add. et del.* P

²⁸⁷ trium circulorum spatium] circulorum trium D

²⁸⁸ sive] vel D

²⁸⁹ pedum] me *add. et del.* P

²⁹⁰ etiam] et ND

²⁹¹ *Z*] et V? PN, etiam R

²⁹² *AK AZ AH*] *AK A* et *AH PR*, *A* et *KA* et et *A* et *H* ND

circulus occultus nominatus est.²⁹³ Qui quadripartito lineis duabus scindatur, quarum plana utrimque per centrum occulti circuli²⁹⁴ longe extra circum producatur. Deinde ipsius occulti circuli hemispherium dextrum in IX, ab puncto²⁹⁵ Z scilicet ad imum, sinistrum²⁹⁶ vero in totidem²⁹⁷ equas partes ab imo ad summum punctum scilicet²⁹⁸ Z sit divisum. Postque regula ad summum punctum Z posita ac inde non mota secundum bis IX divisiones occulti circuli utrimque in linea plana tam extra circum quam intra²⁹⁹ IX imprimes puncta. Facta igitur tam lineae plane quam occulti circuli divisione³⁰⁰ circini pedem unum in puncto proximo³⁰¹ iuxta occulti circuli centrum pone³⁰² in dextra³⁰³ parte, quem³⁰⁴ dilatando quousque³⁰⁵ ad punctum Z pertingat, sicque³⁰⁶ secundum arcum³⁰⁷ verticalium circulorum circinabis. Ac deinde per tertium punctum a centro in linea plana denotatum azimuth tertium ordinabis. Hac itaque ratione reliquis verticalibus circulis duorum³⁰⁸ sibi invicem oppositorum hemisperiorum³⁰⁹ ordinatis simili ratione secundum³¹⁰ puncta IX in linea plana sinistre partis occulti circuli³¹¹ denotata reliquos zumpruz consummabis. Quod ut facilius studiose indaganti³¹² pateat, subiectam³¹³ in pagina descriptam³¹⁴ formulam tenaci³¹⁵ memorie commendet.

²⁹³ nominatus est] appellatur **D**
²⁹⁴ centrum occulti circuli] occulti circuli centrum **D**
²⁹⁵ supra **V**, *om.* **ND**
²⁹⁶ Sinistrum] sinister **ND**
²⁹⁷ Sinistrum (...) totidem] *om.* **R**
²⁹⁸ scilicet] *om.* **ND**, solis **R**
²⁹⁹ intra] extra **N**, infra **D**
³⁰⁰ divisione] pone *add.* **S**
³⁰¹ puncto proximo] proximo puncto **ND**
³⁰² pone] *om.* **D**
³⁰³ in dextra] dextra in **PND**
³⁰⁴ quem] *om.* **R**
³⁰⁵ quousque] quoadusque **P**
³⁰⁶ sicque] Sic **N**
³⁰⁷ pertingat (...) arcum] *om.* **R**
³⁰⁸ duorum] quadrantium *add.* **D**
³⁰⁹ hemisperiorum] *om.* **ND**, hemisperium **R**
³¹⁰ secundum] *om.* **P**
³¹¹ circuli] denoti circuli *add.* **D**
³¹² indaganti] indagantibus **D**
³¹³ subiectam] subiecta **RD**
³¹⁴ descriptam] descripta **VPN**, prescriptam **D**
³¹⁵ tenaci] tenace **V**

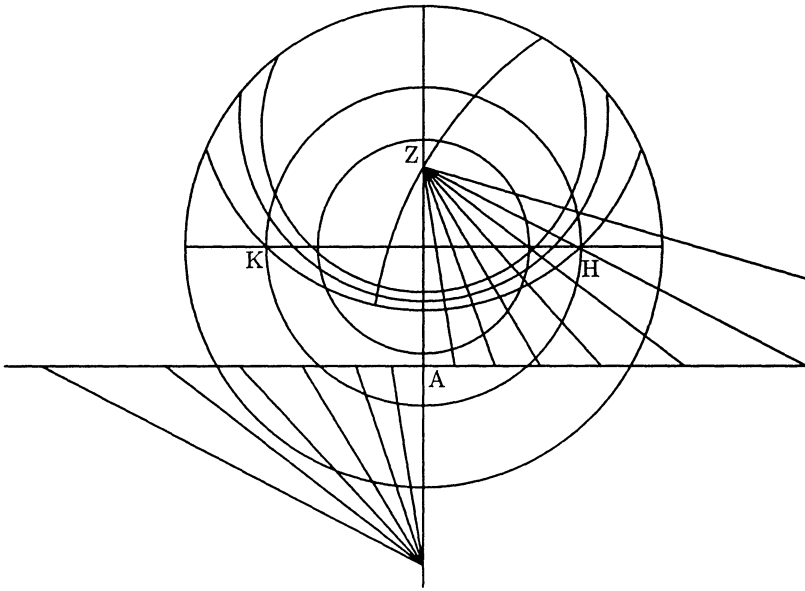


Figure 5

<13 i> Perfecta astrolabii fabrica nunc de utilitate eius que necessaria sunt subiungamus. Ac primum de nadiar Solis: gradu solis ut supra docuimus in dorso astrolapsus invento in halhancabut in ordine signorum eundem gradum require³¹⁶; quo supra primum almucantarath orientem versus posito vel econtrario oppositum almucantarath nadiar solis assignabit.

<ii> Omni hora diei altitudinem solis³¹⁷ sic invenies: suspenso ad radium solis astrolabio alhaidade summitatem sursum gradatim elevando quousque radius solis opposita perlustret foramina; postque quot linee recte alhidade et coluri equinoctialis interfuerint gradus tota erit eodem momento altitudo solis. Eadem ratione altitudinem stelle invenies.

<iii> Altitudine solis et stelle sic inventa horas diei et noctis eadem altitudine invenire poteris: gradu³¹⁸ solis ut dictum est invento et in alhancabut notato supra primum almucantarath versus orientem pone, quem sursum versus meridiem ab eadem linea per³¹⁹ gradus ceterorum almucantarath, quousque numerum graduum

³¹⁶ require] requirere P

³¹⁷ solis] om. V

³¹⁸ gradu] gradus P

³¹⁹ per] supra V

altitudinis solis compleveris, promove. Et sic quotcumque gradus signi orientis in ortu fuerint³²⁰, almucantarath primum ipsos denotabit, nadair solis horam et partem hore presentis demonstrabit. In nocte eodem modo per altitudinem cuiuslibet stelle fixe operare.

<iv> Horis inventis et earum partibus que sint equales et inequales sic dinoscere poteris, si primum de horis equinoctialibus pauca absolverimus. In Arin³²¹ quoque sub circulo recto sito sol totum annum sub equinoctio peragit ibique dies et noctes totius anni semper XII horarum equalium spacio metiuntur; a quo quanto quelibet regio versus utrumque polum remotior, tanto³²² horarum inequalitas maior consequitur.

<v> Nunc quomodo per astrolapsum hore equales in³²³ inequales et econtrario in omni climate redigende fuerint, simulque de arcu diei et solis et stelle cuiuslibet fixe, subiungamus. Gradu³²⁴ itaque solis in volvello³²⁵ notato et super lineam orientalem posito, nota quem in limbo gradum almeri tetigerit. Sicque gradu solis a prescripta linea per medium celi ad occidentalem lineam promoto, ubicumque <...> arcum diei sol per almeri terminat. Reliquum arcui noctis relinquitur, qui per XV³²⁶ sectus horas diei equales terminat; si quid minus superfuerit, partibus unius hore annumeretur.³²⁷ He vero cum³²⁸ <in> inequales redigende fuerint, arcum diei in XII partire, quidque³²⁹ spacio unius hore minus relinquitur in puncta, divisum per horas distribue, heque sunt hore et puncta horarum inequalium. De reliquo arcu noctis eodem modo operare. Nam stelle cuiuslibet fixe arcui diei metiendo, quem³³⁰ per gradum solis et almeri arcus solis dedimus noticiam, per stellam quamlibet in astrolabio positam et almeri de arcu stelle cuiuslibet et eius horis data sufficiat.

<vi> Ad noticiam gradus solis ignoti sic pervenies: accepta altitudine in dorso astrolabii³³¹ medio quocumque die, etiam quot graduum fuerit tot graduum spacium inter orientalem lineam et meridionalem elige, ibique nota impressa quem in alhancabut gradum attingere poterit in eodem proculdubio solem esse recognosces.

On the diagrams

In general the diagrams, which exist only in **V**, **N**, **R** and **T**, have been drawn according to the written text. The principal deviations of the manuscript

³²⁰ fuerint] fuerit MSS

³²¹ Arin] annum P

³²² tanto] tanta P

³²³ in] et P

³²⁴ Gradu] gradus P

³²⁵ volvello] volvelle V

³²⁶ xv] xii MSS

³²⁷ annumeretur] annumeratur P

³²⁸ cum] supra V

³²⁹ quidque] quodque P

³³⁰ quem] quam P

³³¹ astrolabii] astrolapsus P

diagrams are noted here, with the exception of **T**, whose diagrams are so poor that they only seldom deserve a mention.

Fig. 1. The graduations of both degrees and days and the markings of the intervals and of the months are to be understood as going all the way round the diagram. **V** has no degrees, days or intervals; nor has it the requisite circles. **N** has the circles, but no graduations. **R** has both circles and graduations, the interval for the degrees being 7, 15, 22, 30; outside the degree-markings is an extra circle containing the numbers of the degrees of the quadrant, which also increase alternately by 7 and 8 and which start at the beginning of Aries and Libra. The note in the margin is evidently the scribe's explanation of this. In general **R** is very carefully drawn. Both **V** and **N** have an extra pair of lines, horizontal and vertical, in the shadow square within the lines carrying graduations; the diagonal on the lower right is continued to meet their intersection. **N** omits the oblique line through the centre; **R** has only the upper half of it. **V** has an indication of the suspension. **V** has a drawing of an alidade beneath the figure.

Fig. 2. In **R** the diagram is almost obliterated. Some diagram letters seem to be missing.

Fig. 3. The names of the signs are to be understood as going all the way round the zodiac circle; graduations of intervals and degrees are also to be understood. In **R** the intervals (15 and 20) and some of the degrees are given on the zodiac; in **N** there are empty circles; in **V** there are not even circles. In **V** **C** is missing. In both **V** and **N** the indicator at **E** is blunted. The lines to determine the position of a star are shown dotted and represent the first example in the text. For the line indicating the *latitudo ab utraque parte* **V** has a line joining **K** to a point slightly to the right of **E**, and **N** has a line from a point to the right of **E** reaching just past the circle of Cancer. **N** carries the name *munirmen elfeka* to indicate the star. **R** has the traces of lines to find the position of two stars, top right and bottom left.

Fig. 4. **V** has only one oblique line through **H** towards **P**. **N** has **O** for **M**; **N** omits **L**. **V** has two specimen hour lines on the right hand side. **V** has a token line through **H** to find the lower end of an almucantar, apparently that defined by **X**. **V** has an extra diameter, bottom left to top right, about 45° to the vertical. **N** has the sixty blobs on the equator, as indicated, but **VRT** have none. **T** has only two lines from **H**, which no doubt define the ends of the horizon, as if the standard method were being illustrated; **R** is similar, only with two lines for upper limits and two lines for lower limits. Neither has **P**.

Fig. 5. This diagram for the azimuths reproduces **N**, except that the eight azimuths are here represented by one token one. **V** labels the point **A** (see Fig. 5a). **V** includes a 'hidden circle' through **K Z H** and the lowest point. In **V** the azimuths appear to have been drawn in two parts: from lower left to **Z**

and from Z to upper right. There is no evidence in the written text that lines were to be drawn from the lowest point, and not Z, to find the almucantar-centres on the left. Fig. 5a is intended to illustrate the text. In **T** all the azimuths are partial, starting from Z and going upwards; it is like a poor version of **V**, the letters being badly muddled. In **R** all the radial lines come from Z on both sides; there are numerous azimuths, continuous and whole.

Titles of the work

V: [none]

P: dilectissimo domino suo Iohanni dd' Rodolfus brugensis hermanni secundi discipulus scribit

N: [none]

R: Opus distrolabii breve secundum radulfum burgensem hermanni secundum discipulum

D: Rodulphus brugensis [later hand]

Titles of the sections

1. **R:** descriptio dorsi astrolabii et primo circuli signorum
D: Capitulum primum de postica et de circulis signorum
2. **R:** descriptio circuli mensium
D: Capitulum secundum de circulis mensium
3. **R:** ordinacio circuli signorum et mensium quadrantem
D: Capitulum tercium de ordine signorum et mensium
4. **R:** descriptio mesure quadrante
D: Capitulum de quadrato
5. **R:** assignatio figure que dicitur alkaidade
D: Capitulum v de regula
6. **R:** descriptio duorum tropicorum et equinoccialis in plano
D: de tribus circulis
7. **R:** descriptio alankabuz sive volvelli sive retis
D: de alancabut
8. **P:** de positione stellarum fixarum in hancabuth
R: opus ordinandi claviculos stellarum fixarum in volvello
D: de stellis fixis
9. **R:** locacio limbi et elmeri sive calculatoris et eius utilitatibus
10. **R:** opus locationis almucanterath ad omnem latitudine<m> regionum
D: de latitudine et almucantarar
11. **R:** opus in ponendo lineas horarum

D: de horis dierum
12. R: opus in describendo azimuth sive zumprut sive circularum
verticalium et e[orum] utilitates
D: de asumuth

Marginal note in R against the last lines of section 1:
addidi autem intervallum inter gradus et signa in quo scripsi numerum
graduum singulorum signorum propter evidentiam in exteriori non
intervallo scripsi unum graduum singularum quartarum.

Star table

no.	[name]	signa	longitudo		latitudo		modern name
In plaga septentrionali he primum collocanda sunt							
1	Munirmenelfeca	Scorpius	10	0	49	0	α CrB
2	Razalhawi	Sagittarius	8	37	36	0	α Oph
3	Annaceralwaka	Capricornus	1	27	62	0	α Lyr
4	Denebadigeia	Aquarius	23	17	60	0	α Cyg
4a	Aramec	Libra	24	27	65	5	α Boo
5	Delfin	Capricornus	25	10	59	3	ε Del
6	Wela	Capricornus	1	15	72	0	α Lyr
7	Alrifh	Capricornus	19	3	73	7	α Cyg
8	Alhoc	Taurus	10	41	71	10	β Per
9	Alhaioc	Gemini	3	20	74	13	α Aur
10	Egregez	Cancer	26	9	72	9	μ Uma
11	Alrucuba	Leo	19	1	75	20	θ Uma
In parte australi he similiter collocentur							
12	Rigil argebal	Gemini	3	57	57	31	β Ori
13	Zoel	Gemini	29	0	65	0	α Car
14	Aschare alabur	Cancer	1	47	39	11	α CMa
15	Aldebaran	Taurus	27	2	59	0	α Tau
16	Algeuze	Gemini	18	5	60	0	α Ori
17	Algomeiza	Cancer	13	7	56	25	α CMi
18	Aldiran	Leo	6	10	52	0	(α Hya)
19	Calbalacet	Leo	18	1	61	6	α Leo
20	Lidineb	Aquarius	8	20	35	7	δ Cap
21	Deneb kaituz	Pisces	20	0	26	0	ι Cet
22	Algurab	Virgo	18	0	41	0	γ Crv
23	Alcimech	Libra	8	11	39	50	α Vir
24	Calbalacrab	Scorpius	25	0	14	55	α Sco

supra tabulam]²⁹ positio tabule stellarum fixarum **R**

[name]] Muniri **V**, in parte septentionis **D**; signa] *om.* **R**; *sub* longitudo]
gradus punctum *add.* **V**; *sub* latitudo] gradus punctum *add.* **V**

In plaga (...) sunt] *om.* **D**; he] *om.* **R**; collocande sunt] collocando **R**

1) Munirmenelfeca] Munirmelfeca **D**

2) Razalhawi] Bazalhawi **VR**; 8] xii, 5 **VR**; 37] xii, 27 **N**, 38 **R**; 0] xii, 15 **N**

3) 27] xii, 0 **N**; 62] xii, 52 **N**

4) 17] xii, 37 **N**; 60] xii, 63 **VR**

4a) Aramec] Alramech **D**; *om.* **VR**; 27] 0 **D**

5) Delfin] Delphin **R**; 10] 17 **N**

6) 15] 0 **N**

7) Alrifh] Alrip **N**, Alriph **D**; 19] 29 iii; 3] 10 **N**

8) 41] 61 **VR**, 15 **N**

11) Alrucuba] Jalrucuba **VR**; 1] 50 **R**

In parte (...) collocentur] In parte australi he collocentur **N**, similiter hec in plaga
meridiana **R**, In parte australi **D**; gradus puncta gradus puncta *add.* **N** *super*
columnas; signa longitudo latitudo *add.* **D** *super columnas*

12) argebal] argebar **ND**; 3] 12 **VR**

13) Zoel] Zohel **D**; 29] 39 **VR**

14) Aschare] Ascare **N**, Aschar **D**; 11] 9 **R**, 10 xii

15) Aldebaran] Adebaran **N**

16) Algeuze] Abgeuze **R**

17) 13] 14 **ND**, 11 iii; 56] iii, 66 **N**

18) Aldiran] Aldiraain (-aam?) **N**; 6] iii, 14 **VR**

19) Calbalacet] Cabalacet **N**, Calbalac **R**; 18] 6 **VR**, 19 iii; 6] 3 **ND**

20) 8] 18 **VR**, 7 iii

21) kaituz] kairut **VR**; 20] 8 **VR**; 26] 35 iii

22) 18] 20 **VR**

23) Alcimech] Acimec **N**; 8] iii, 18 **VR**

24) Calbalacrab] Calbalacrap **ND**, Calbalcrab **R**

²⁹ In the list proper the variants are noted for each line, which is indicated by its number followed by a right square bracket. 'iii' or 'xii' following a reading refers to Kunitzsch, *Typen*, 28 and 78-79 resp., where these star lists are edited. They are inserted to show why one manuscript reading is preferred to another. The choice of reading for the minutes of type-iii stars, which normally have no minutes, may sometimes be justified (e.g. N's 17 in star 5 may have fallen from the previous line), but sometimes must be decided by the numbers of manuscripts supporting the readings or by pure guesswork. The numbering of Kunitzsch's edition, from **V**, in the appendix to his 'Messahalla' has been retained, so that Aramec, not in **V**, carries the number 4a. Of course, the first and last columns are modern editorial additions.

Translation

Since it is clear that the various position[s] of the celestial spheres bring to the world below the various risings and the various settings of the stars and [since] it is possible that a description of this variety be represented in the plane, just as it appeared to Ptolemy and his follower Maslama, who is called al-Majrīfī³⁰, Rudolfus of Bruges, disciple of Hermannus Secundus, describes to the best of his ability the construction of this instrument for his most esteemed lord Johannes David.

[1. The back of the astrolabe]

The first [part to be described] of this instrument is the back, which some call the *mater*, because under its rim the other plates are contained like children in the mother's womb. This is divided totally into two equal [parts] by a vertical line from the top, where it is suspended by linked rings, and descending through its centre. Then, when one of the feet of a pair of compasses is fixed at the same centre, at the edge of the same plate a circle is drawn, which is divided into two equal [parts] by a horizontal [*plana*] line—into an upper hemisphere and into a lower [hemisphere]—with this precaution, that these two lines, i.e. vertical and horizontal, dividing the whole circle into four parts, intersect in the middle at the centre of the circle. This done, inside this circle let three circles be drawn, distant from one another, for containing the degrees, the intervals and the signs. When, therefore, the division of the circles into four has been made, let each quadrant be subdivided into three, which we assign to the placing of the twelve signs. Let each of these twelve be divided again into six intervals comprising five degrees. The whole circle [*circuitus*] will by this procedure be divided into 360 parts.

[2. On the circle of the months]

Having set down the circle of the signs, let us now turn to the setting down of the circles of the months. For since the apsis of the Sun does not depart from the 18th degree of Gemini, and there, by almost two and a half degrees, the centre of the excentric circle is raised from the centre of the *circulus rectus*, it is necessary for the same reason that the centre of the circles of the months be raised from the centre of the above-mentioned circles. When one of the feet of the compasses has been placed in the middle of a space comprising five degrees in the greatest circle and the other at the end of the same space so that the feet of the compasses include two and a half degrees, let a circle be afterwards drawn with the same space about the centre of the above-mentioned circles, though of a very small size. Then when a rule is aligned from the 18th degree of Sagittarius to the 18th degree of Gemini, where the line from the centre on the Gemini side meets the very small circle, there one of the feet of the compasses is fixed, and the other is brought out towards Gemini; you draw a circle as large as you can, but you take care that it does not touch the smallest circle of the signs. Thus you find the excentric circle of the Sun. Inside it you draw three others, as reason demands, about the centre of the excentric circle. The division of them is as follows: in the first place let the two outermost arcs of the whole lower hemisphere be divided into six equal parts, each of which are subdivided into six intervals, and let each of them again be subdivided into five. Thus you will set up

³⁰ In the text in the corrupt form Aoukakechita, etc. For the identification with al-Majrīfī (i.e. from Madrid), see Kunitzsch, 'Messahala', 57.

180 days in the lower hemisphere. Then, when the space of five days has been taken from the end of the arc of the upper hemisphere, let the remainder be separated again into six parts; each of them is subdivided into six-times-five days. You will find in the total arc of the upper hemisphere, adding the space of five days that we took from the same arc, 185 days; and thus in the whole circle you will complete together 365 days.

[3. *On the circles of the signs and of the months*]

Since these circles have now been obtained, there now follows the laying down of the signs and the months. Since, therefore, a division-into-four of the circles of the signs and of the months has been made by two lines, i.e. vertical and horizontal, to make the laying down of the above-mentioned [signs and months] easier, let us add descriptions of the lines: the one that is drawn from the first centre to the left side of the back is called 'east', [the one drawn] from the same centre to the right is 'west', the one that rises from the same centre towards the armilla is 'south' and [the one] descending to the bottom, is 'north'. Although we put Aries in the first place in the circle of the signs, we by no means hold the month in which the Sun traverses the first degree of Aries as worthy to be put in the first place in the order of months. We place Aries in the amount of 30 degrees [starting] from the west line upwards towards the south in the circle of the signs. From the same point of that line from which Aries takes its beginning we allot, in the circle of the months, 16 days to the month of March [going] upwards towards the south. Then after Aries [going] towards the south we put Taurus and Gemini; after the south [line] we depict Cancer, Leo and Cancer [arriving] at the east line; from the east line to the bottom Libra, Scorpius and Sagittarius are inscribed; from the bottom to the west line Capricorn, Aquarius, Pisces are laid down. After March in the circles of the months we assign, again [going] upwards towards the south, 30 to April, 31 to May; then, from the south to the east 30 to June, 31 to July, 31 to August; and likewise, from the east to the bottom, 30 to September, 31 to October, 30 to November; and then, from the bottom upwards towards the west line, 31 to December, 31 to January, 28 to February; and then to March we add the 15 which were left over.

[4. *On the shadow square*]

After these things have been so constituted, let us now investigate the measure of the square, in which physical investigation is devised with no small expertise in geometry. But in order that the instruction of this description becomes adequate [we proceed thus]: first, about the first centre and inside all the other circles we draw two circles with a very small distance between them; then we divide each quadrant of one circle into two equal parts. Then between the two points of the lower hemisphere [just constructed] we draw a straight line and between the two points of the upper hemisphere [we draw] another line opposite this one: these lines will be parallel to each other. Then we draw a line from the right extremity of the upper line to the right extremity of the lower line; opposite this we construct a fourth line with the same procedure. Having thus constructed these [lines], you will have a rectangular, equal-sided quadrilateral, but since a quarter of this can suffice for geometrical measurements, we choose that which is opposite Leo.³¹ When four lines have been

³¹ From the diagrams in VNR it is clear that 'opposite' here means 'diametrically opposite', not 'facing'.

constructed inside the sides of this square, meeting at right angles to each other [two by two], let them all be divided into six equal parts, each of which is subdivided into two—by this arrangement, that the upright side of this square is divided into 12 and the horizontal into as many.

[5. *On the alidade*]

These things on the back [of the instrument] have been set out by us as compendiously as possible. But in order that they be easier to understand for the inexpert as much as for studious investigators, let the things described in the present plate [*spera*] suffice. On this [the back] there is an alidade, i.e. a rotatable line, which some call a ray [*radius*]. Having brought it to the individual marks of the days, through the present day known to us of any month, if the rule is not moved from this place, we can find the degree of the Sun, whatever sign it is in. Conversely, through the degree of the Sun known to us we can find, by the reverse procedure, the present day of the present month. On this [the alidade], i.e. at its end[s], two sights [*pinne*] are made fast, erected perpendicularly, [each] perforated in two places in alignment, so that with the two narrower [holes], when aligned [with the Sun] the altitude of the Sun—[or] with the broader ones the altitude of the stars—may be distinguished.

[6. *On the equator and tropic circles*]

Then follows a description of finding three circles, of which the middle one has the function and name of the equinoctial circle. On either side of it [lie the other circles]—the maximum declination of the Sun is measured on each circle. This maximum declination of the Sun is, as Ptolemy wishes, $23^{\circ}55'$, though some measure [it as] $23^{\circ}35'$; but since there is little difference, let us propose [to take] Ptolemy's statement [into use], as he is taken as of rather great authority among the astronomers [*astrologi*]. Let a plate be made of the size of the area [*planicies*] contained within the rim. In this, about centre *A*, let the greatest circle of the three be drawn so that it [just] does not touch the extreme edge of the plate. Let the [circle] be divided by four points at the ends of two lines intersecting at the centre *A*: let *B* be the east point; *C*, opposite it, the west point; *D*, above, the south point, *E*, below, the north point. Then let arc *DB* be divided into three portions, of which let the one closer to *B*—or to *D* if that is more pleasing—be divided into five graduated partial intervals. Mark the point *F* at the end of four spaces [going] from *D* towards *B*; then lay a rule on point[s] *C* and *F* and put the point *G* where the south line is met by the rule, and so drawing the equinoctial circle *GHIK* on centre *A* and with distance [*A*]*G*. By the same procedure you will also devise the smallest circle *LMNO* by means of the equinoctial. To make it more easily apparent, the figure placed below shows it.

[7. *On the rete*]

After three circles have been determined, there follows a description of the rete [*hankabuth*], which some call *volvellum* and some *rete*. When one of the feet of the compasses is fixed somewhere in the north line so that the other foot on either side reaches points *E* and *L* at the same opening, then with the same opening let the inclined circle, which is also called 'the path of the Sun', be drawn—with this precaution, that it intersects the equinoctial the middle through the middle, [say] at points *H* and *K*. Inside this [circle] let three other circles be drawn. Let all four be divided into signs and intervals according to the partition of the greatest circle. When the division of the greatest circle has been made, i.e. into 12 signs and afterwards into 72 intervals, let a rule be put on the centre of the three circles and then, not being moved [from there], placed at the individual divisions of the greatest circle: where it meets the path of the Sun, the line will cut the zodiac [at the corresponding

point, which may be marked; this process is continued] until you have subdivided the whole zodiac into 12 signs and the same into 72 intervals. These are constituted now shorter and now longer, according as the *rationale* of the inclined circle demands, for if you knew the *rationale* of the distance of the inclined circle from the direct [*rectus*], you would not wonder at the inequality of the two hemispheres of the inclined circle. Whoever desires to know the *rationale* of this inequality may read Ptolemy's *Planisphaerium* translated by Hermannus Secundus, but lest the [things] written above trouble the reader's mind, they are made clear in the drawn representation of this *volvellum*.

[8. *On the fixed stars*]

Now it is appropriate to construct on the rete the pointers [*claviculī*] of some of the stars, the points of which we use in place of the stars in measuring arcs of night, taking the nocturnal hours and establishing the houses. But lest an excessive prolixity of language cause the reader delay, their names, longitudes, latitudes—and which are northern and which southern—as al-Khwārizmī and other philosophers teach, we make clear in a table [*figura*] drawn up shortly below. For example, so that the approach becomes easier, we shall establish the place of one [star] from the beginning [of the table], Munirmenelfeca, which our contemporaries call 'the shining one', northern, placed in the 11th degree of Scorpius, its latitude being 49°. Its position is found in this way: having placed the rule on 11° of Scorpius and on the centre of the three circles, you draw a line between the two ends; so, having found its longitude, count 49° on each side of 11° of Scorpius. When points have been marked at their ends, the rule is placed over the same [points] and where it meets the line of longitude is where you know the position of that star to be. You will adapt for it a pointer [*denticulus*] at whose vertex the star is seated, as is shown in the aforementioned figure. Now this [star] has been placed, it is appropriate to place a southern [star] by way of an example: Rigilalgebar, i.e. Orion's foot, placed in 3° of Gemini, its latitude being 57° south, so that it is suitable to find its position. When the rule has been placed on the aforesaid centre and on the third [degree] of Gemini, let a straight line be produced through them to the circumference of the greatest circle. Some point being marked there, you will mark off [arcs of] 57° on the same greatest [circle] on both sides with two points. Where the rule placed on these meets the line drawn from the centre of the circle through 3 Gemini to the circumference you mark the place of Orion's foot and fix the root of its pointer on the equinoctial circle. By this procedure are found the positions of the other fixed stars, by which you obtain knowledge of both the rising [degrees and celestial bodies] and of the hours. Their [sc. the stars'] description is put below.

[*star table*]

[9. *On the rim and the pointer*]

Outside the greatest circle touching the rim [*umbo*], which is also called *limbus*, we drew another circle. From this we have cut off an arc of 30°, i.e. from 15° Sagittarius to 15° Capricorn. In the middle of this arc there protrudes a pointer [*denticulus*]—which is also called *almeri*, i.e. limiter, and *calculator*—, so that, when the circumference of the rim has been divided into 360 degrees for the nearer [part] of the pointer and into 72 intervals for the further [part]—so that the counting is made easier by these degrees and intervals—you can find out by this *calculator* with how many degrees in the equator circle each of the signs rises in the various regions, the divisions of the intervals of the almucantars and of the hours and other things of this sort.

[10. *On the almucantars*]

When you want to know the latitude of any region anywhere in the world³² place the three circles as above in the plate *plana spera* [i.e. *ṣaḥīḥa*], i.e. the equator and the two parallels; on which the rete, inscribed with the signs and their degrees, is placed appropriately, the degree of the Sun having been determined; and then, on the back of the astrolabe, take the altitude of the Sun at midday in the place you are in. Noting this on a writing-tablet [*cera*], put the degree of the Sun on the south line. Then divide the total altitude into 6—if anything less than 6 remains, leave it on the upper side of the point that we denoted by the degree of the Sun. Then, putting a line on *H*—and then, not moving it [from there, but making it pass] through the divisions of the equinoctial circle—and on the point denoted by the degree of the Sun, you will set down the aforementioned parts of the Sun's altitude in the south line. E.g. in 1144 AD in Béziers in Gotia near the Mediterranean Sea, wishing to make a plate for the latitude of this region—on the 24th day of April the Sun occupied the fourth degree of Taurus and its altitude was 62°, which is divided by 6—we collected 10 intervals. To these only two degrees are left over. Therefore, putting the degree of the Sun on the south line, we there put point *P*. Then we subdivide the whole equinoctial circle into 60 intervals. This done, [we take] a rule placed on point *H* and³³ on some point in the [upper] left quadrant so that it arrives as near as possible at point *P*, and there we mark the first point of the first of the ten intervals, which we took above from the altitude of the Sun. Then, by raising the rule higher in the south line according to the intervals of the equator circle as far as *Q*, far outside the circle, we establish ten intervals. Then again [raise] the rule under *P*, [...] lower in the same north line [i.e. the northern, or lower, part of the meridian], for the various partitions of the equator circle, as above, and we count ten intervals. At the end of these we mark point *R*.

With 30 intervals in the meridian line being thus completed, i.e. between points *Q* and *R*, there follows [an account] of the drawing of the almucantars. Having fixed one of the feet of the compasses in the middle between *Q* and *R*, the other being extended on both sides to the same points, we draw the first of the almucantars from *S* through *H R K T*. By the same procedure we draw the second [almucantar] between *V* and *X*; and in order we finish the other *orbiculi*, some complete and some half-complete, as reason demands, up to the central point of the fifteen *orbiculi*, which is the centre of the vertical circles, by some nations called *centaroz*.³⁴

[11. *On the hour lines*]

Having established the *orbiculi* of the upper hemisphere, it remains for us to draw the lines of the hours, as reason demands, in the lower hemisphere. When the arcs which the first of the almucantars of the upper hemisphere cuts off, i.e. *SET HIK YNZ*, have been divided, each in 12 parts, let one of the feet of the compasses be placed somewhere, either on the plate or far outside it, so that the other foot extends equally to the three divisions that we had made in the three arcs and we thus draw the first line of the first hour. By this procedure we also establish the rest of the lines of the hours, now shortening and now lengthening [the span of] the compasses: six on one side of the north line and as many on the other—as we have made clear in [the diagram of] the plate [*spera*] mentioned above.

³² *Lit.*, 'each region everywhere of the countries'.

³³ 'if necessary' is added *supra* in VP and *in textu* in R

³⁴ From the Arabic *samt al-ru'ūs*. See Kunitzsch, 'Glossar', 547.

[12. *On the azimuths*]

Now that [the method of] finding the latitudes of the various regions has been given³⁵, it follows that we [can] add something on the vertical circles, which some call *azimuth*, but others *cenit capitum* and [yet] others *zumpruz*³⁶, and which are common in the usage of the Saracens so that they know in which direction to say their prayers. We, however, with a little effort, [also] draw them on our instruments, so that through them we can understand the distance of the rising and setting of the luminaries from the equator circle every day and everywhere on Earth. Let a line be produced, in the direction of the north line, far outside the circle, and let one of the feet of the compasses be fixed on it either inside the space of the three circles or somewhere outside, so that the other foot extends simultaneously to the middle point of the 15 *orbiculi*, which we designate by point *Z*, and to the equinoctial points *H* and *K*; and, this done, let a circle be drawn, which by some is named the 'hidden circle' [*circulus occultus*] to the measure of the three spaces, i.e. *AK AZ AH*. Let this [circle] be cut into four by two lines, of which let the horizontal one, through the centre of the hidden circle, be produced far outside the circle on both sides. Let the right hemisphere be divided into nine [equal parts], i.e. from point *Z* to the bottom, and the left hemisphere into as many equal parts from the bottom to the top, i.e. point *Z*. Then, placing the rule at the top point *Z* and then not moving it, you mark nine points on both sides, according to the twice-nine divisions on the hidden circle, on the horizontal line both outside and inside the circle. Having made the division of both the hidden circle and of the horizontal line, put one foot of the compasses on the nearest point next to the centre of the hidden circle on the right side, opening the [compasses] until they extend to point *Z*, and so you draw the second arc of the vertical circles. Then, through the third point from the centre marked on the horizontal line you construct the third azimuth. Having constructed the remaining vertical circles of the mutually opposite hemispheres by the same procedure, you will finish the remaining *zumpruz* by a similar procedure according to the nine points marked on the horizontal line of the left part of the hidden circle. In order that it become clearer to the diligent investigator, let him commit to his tenacious memory the diagram [*descripta formula*] put below on the page.

[13. *Uses of the instrument*]

[i] Having finished making the astrolabe, we add what is necessary of its use. First on the *nadir* of the Sun: having found the degree of the Sun, as we described above, on the back of the astrolabe, seek the same degree on the rete in the series of the signs; when this is placed over the first of the almucantars³⁷ on the east side or vice versa, the opposite [side of the] almucantars will indicate the Sun's *nadir*.

[ii] At every hour of the day you will find the altitude of the Sun thus: when the astrolabe is suspended towards the ray of the Sun, and when one raises the tip of the alidade little by little until the Sun's ray shines through the [mutually] opposed holes, thereafter however many degrees lie between the straight line of the alidade and the equinoctial colure will be the total altitude of the Sun at that moment. By the same procedure you will find the altitude of a star.

³⁵ This no doubt refers to the beginning of part 10, but no method was given there.

³⁶ I.e. *samt al-ru'ūs* in both cases. *ru'ūs*, the plural of *ra's*, 'head', is translated in the first term. Both properly mean 'zenith', not 'azimuth'. See Kunitzsch, 'Glossar', 546-548.

³⁷ I.e. the horizon.

[iii] Having thus found the altitude of the Sun and of a star, you will be able to find the hours of the day and night by means of the same altitude. Having found the degree of the Sun, as has been said, and marked it in the rete, put it over the first of the almucantars in [*versus*] the east and move it upwards towards the south from that line [i.e. towards the meridian from the eastern part of the horizon] through the degrees of the other almucantars until you complete the number of the degrees of the Sun's altitude. Thus as many degrees of the eastern sign as are rising, the first of the almucantars will indicate them [and] the Sun's *nadir* will show the hour and the part of the present hour. At night proceed in the same way with the altitude of any star.

[iv] Having found the hours and their parts, you will thus be able to distinguish which are equal and [which are] unequal if we have first dealt with a few things concerning the equinoctial hours. Also, in Arin³⁸, situated under the equator circle, the Sun goes through the whole year under [the circle of] the equinox³⁹; and there the days and nights of the whole year are always measured by the span of twelve equal hours. The further any region is from this [sc. the equator] towards either pole, the inequality of the hours is consequently greater.

[v] Now let us add an account of how equal hours are to be reduced to unequal [hours] and *vice versa* for every climate and at the same time [an account] of the arc of day both of the Sun and of any fixed star: having marked the degree of the Sun on the *volvellum* and put it on the east line [i.e. the eastern part of the horizon], note which degree in the rim the *almuri* touches. Thus, when the degree of the Sun is moved forward from the aforementioned line through the meridian [= *medium celi*] to the west line, wherever [it meets it], the Sun determines the arc of day through the *almuri*. The rest is left for the arc of night. This [sc. the arc of day], divided by 15⁴⁰, determines the equal hours of day. If anything less [than 15°] is left over, it is added to the parts of one hour. But when these [equal hours] are to be reduced to unequal [hours], divide the arc of day into 12—what is less than the span of an hour is left as *puncta*; distribute the divided [number] among the hours—and these are the hours and *puncta* of the unequal hours. For the remaining arc of night proceed similarly. For measuring the arc of day of any fixed star, [to find] which we have given the procedure of the Sun's arc [of day] through the degree of the Sun and the *almuri*: through any star placed on the astrolabe and the *almuri* may the given [procedure] suffice.

[vi] You will arrive at knowledge of the unknown degree of the Sun thus: having taken the altitude on the back of the astrolabe at midday on some day, select as many degrees as there are [in the altitude] also on the space between the east line and the meridian⁴¹, putting a mark there, and you will recognize whichever degree in the rete can attain [this altitude] as [the position of] the Sun in the same.

³⁸ The Ujjayn of Indian astronomy, here taken as zero latitude as well as zero longitude. It was called the 'cupola of the world' (see Bīrūnī, India, and al-Ḥashimī, p. 217.)

³⁹ This part of the sentence is unclear. Of course, the Sun is on the equator only twice a year.

⁴⁰ The manuscripts have 12. Division by 15 yields the number of equal hours in the day. Division by 12 yields the length of the unequal hours. In both divisions here the fractional part is treated strangely.

⁴¹ This appears to be another reference to assessing altitude by counting the almucantars from the eastern part of the horizon.

Summary and comments

In the preliminary paragraph Rudolf mentions as his predecessors only Ptolemy and his 'sequax' Maslama. By Ptolemy is probably meant the *Planisphaerium* rather than other texts ascribed to Ptolemy—the third part of the *Sententie*, Millás's II C, and Millás's XII do not seem to have influenced Rudolf particularly.⁴² By Maslama is probably meant the notes and appendices to the *Planisphaerium*, though Ibn al-Šaffār's work, sometimes taken as by Maslama, is also possible. As will shortly be clear, Rudolf must have had access to some other work, on the construction of the astrolabe.

§1. As with all graduated circles, Rudolf constructs the zodiac circle by altogether four circles, the outermost of the intervening spaces being filled with degrees, the middle space by five-degree intervals, and the innermost by the names (here of the signs).

§2. The circle of the months is drawn excentrically within the zodiac, the centre being set at chord($2\frac{1}{2}^\circ$) from the centre of the zodiac on the line towards 18° Gemini. Numerically the excentricity accords well with Ptolemy's value of $2;29\frac{1}{2}$ parts (where the radius of the circle is 60 parts), which he approximates to $2\frac{1}{2}$ parts, for the excentricity of the Sun's deferent.⁴³ For chord($2\frac{1}{2}^\circ$) is approximately $2;37$ parts of the months-circle. But the $2\frac{1}{2}$ degrees are taken from the largest graduated circles of the zodiac, so that the actual agreement with Ptolemy is not exact. In the same passage Ptolemy finds that the direction of the excentricity is Gemini $5;30^\circ$. The figure 18° is probably taken over from the Toledan tables, which give $17;50^\circ$.⁴⁴ Al-Battānī finds an excentricity of $2;4\frac{3}{4}$ in the direction of Gemini $22;17^\circ$,⁴⁵ though Poulle reports a manuscript, apparently of Battānī, that gives $17;50^\circ$.⁴⁶

The division of the months-circle into 365 days is made by taking the 'lower hemisphere', the part cut off by the horizontal line that bisects the zodiac, and dividing it into 180, extending the graduations by five days into the other part of the circle, and dividing the remaining arc into 180. The idea behind this procedure appears to be as follows: an arc of 180° less about 5°

⁴² See Millás, *Assaig*, 280-288 and 322-324 for the texts; also Kunitzsch, 'Glossar', 477-478 and 481.

⁴³ See Ptolemy's *Almagest*, Transl. G. J. Toomer, London 1984, 154-156.

⁴⁴ G. J. Toomer, 'A survey of the Toledan Tables', *Osiris* 15 (1968), 5-174, this on p. 45.

⁴⁵ *Al-Battānī sive Albatēnī Opus astronomicum*, ed. C. A. Nallino, 3 vols., Milan 1899-1907, I 44, 214; also in the Latin translation by Plato of Tivoli, MS Paris, Bibliothèque Nationale, latin 16657, f. 25. In both cases the distance from the beginning of Aries is given as $82;17^\circ$.

⁴⁶ Poulle, 'Raymond', 877, n. 3, citing MS Paris, Bibliothèque Nationale, latin 14704, f. 116r.

(twice about $2\frac{1}{2}^\circ$ caused by the excentricity) is taken and divided into 180 days; an arc equal to five of these days (i.e. ca. 5°) is taken from the remaining arc; and what is left is divided into 180. This interpretation is suggested by the almost vertical direction of the line of centres and the amount of chord($2\frac{1}{2}^\circ$) between the centres. As described, the procedure makes each day in the upper hemisphere too big and each day in the lower hemisphere too small, the maximum accumulated error being about $2\frac{1}{2}$ days. Clearly, Rudolf would have done better by taking $2\frac{1}{2}^\circ$, not 5° , from the lower arc; and in fact the chord($2\frac{1}{2}^\circ$), which is taken from the greatest circle, would, on our diagram, reduce the lower 180° by about 5.7° .

§6. Ptolemy's value for the obliquity of the ecliptic is given as $23;55^\circ$. In the *Planisphaerium* the values $23;51^\circ$, $23;51,20^\circ$ (the value in the *Almagest*⁴⁷) and 24° all occur.⁴⁸ Rudolf says he will settle for Ptolemy's value, but in fact uses 24° . For arc *DB* is divided into three parts, one part is subdivided into five—making each subdivision equal to 6° —, and the point F is placed at the end of four of these subdivisions.

§7. The zodiac circle is divided by copying the uniform divisions of the greatest circle on the plate onto the zodiac circle by means of a rule. For the copying method to work, one must take the right ascensions of the various signs on the greatest circles, not just 30° for each sign.⁴⁹

§8. In the method described of putting the stars on the rete the 'longitude' is the *mediatio*, i.e. the longitude of the co-culminating point of the ecliptic, and the 'latitude' is what is elsewhere called the *latitudo ab utraque parte*. From the end of the radius defined by the 'longitude' two arcs equal to the 'latitude' are taken on the greatest circle, one each side. Where the line joining the end-points of these arcs meets the radius is the position of the star.⁵⁰

The table itself is something of a mixture, compiled from at least two sources, of type iii, the oldest extant list of astrolabe stars in the west, and of type xii, a western derivation of al-Zarqälluh's list for 1066-67. Most of the stars, nos. 5-11 and 15-24 are of type iii, for which indeed the coordinates are *mediatio* and *latitudo ab utraque parte*. But stars 1-4 and 12-14 have ecliptic longitude, nos. 2, 3, 4, 12 and possibly 14 being taken from type xii.

⁴⁷ See Ptolemy's *Almagest*, 63, n.75.

⁴⁸ *Claudii Ptolemaei opera* II 229, 234, 259, i.e. in Heiberg's sections 1, 4, 20, respectively.

⁴⁹ The method is described in Maslama's *Extra-Chapter*. See Kunitzsch and Lorch, 'Maslama's Notes', 55 and 61. See Poulle, 'Raymond de Marseille', 869, where he says that the mistake is common in the twelfth century.

⁵⁰ For a discussion of this 'latitude', see E. Poulle, 'La fabrication des astrolabes au moyen âge', *Techniques et Civilisations* 4 (1955), 117-128, this on p. 125B (here and later the left- and right-column will be indicated by A and B).

Two stars are included twice, apparently because the compiler of the list failed to realize their identity.⁵¹ Nos. 1 and 12 are mentioned in the text as examples, albeit without minutes of the coordinates (and with 11° for 10° in the 'longitude' of no. 1), and so cannot have been added by some other author.

§10. Most of this section describes a method of finding on the meridian (or vertical south-north line) the two extremities of each almucantar by using the observed altitude of the Sun in a known position in the zodiac (and hence on the rete). The usual method of finding the end-points of the horizon does not use an observed altitude, but needs the local latitude (here ϕ): one draws a line through H (see diagram) and through a point on the equator distant ϕ from H in the upper right quadrant and another through H and through a point distant ϕ from K in the bottom left quadrant. These lines intersect the meridian at the end-points of the diameter of the horizon. The next almucantar, of height, say, h , is found similarly, but taking points $\phi + h$ from H and $\phi - h$ from K , and so on. Rudolf apparently wishes to draw these circles without knowing ϕ , though the initial 'If you want to know the latitude of any region (...)' is curious. As for the rest, the following is offered as an explanation. The number of almucantars is 15, one for each 6° . The observed altitude is divided by 6 to get the number of almucantars—say n , in the example 10—that are beneath the observed altitude. The equator circle is now divided into 60 equal parts. The division of the equator is now found for which the line joining it to H comes as near as possible to P , the point on the meridian corresponding to the known position of the Sun on the rete; and the intersection of the line with the meridian is marked. Then the next division (to the right) is joined to H and the intersection of the line with the meridian is again marked. This procedure is repeated until n marks are made, the last, and furthest from the centre, being labelled Q . The procedure is continued below P and $29-n$ marks are made, the last being labelled R —the $29-n$ being composed of $2(15-n)-1$ for both ends of the almucantars above the observed altitude (-1 because one of the almucantars is degenerate, comprising the zenith, and so needs only one point) and n for the lower ends of the almucantars beneath the observed altitude. In the text Rudolf overlooks the divisions for the almucantars above the observed altitude. The horizon is drawn by taking the mid-point between Q and R as centre and drawing the part of the circle through them that lies between the horizon and the circle of Capricorn. The second almucantar is drawn by using the next pair of points, V and X .

⁵¹ See Kunitzsch, 'Messahala', 59. Stars nos. 3 and 4 are the same as nos. 6 and 7.

The weakness of the construction lies in the placing of the points on the equator-circle. These should begin at a point distant φ from H , but Rudolf merely says 'we subdivide the whole equinoctial circle into 60 intervals', so that he presumably begins with one of the points defined by the quartering lines. In the case of Béziers ($\varphi = 43;20^\circ$) the result would not be very inaccurate, because there would be a division at 42° from H , so that each of the divisions would be only $1;20^\circ$ out, but for some places it could be as much as 3° . Further, it is not clear what is done with the remainder after the division of the observed altitude by 6.

Clearly, the method could be refined by, e.g., dividing the equator circle into 360 parts and leaving the observed altitude undivided (thus obviating the problem of dealing with the fractional remainder). In the example the equator division that most nearly corresponds to 62° of altitude would easily be found—there would only be an error of $20'$ —and the division corresponding to 60° and hence of the other values for which almucantars are desired could also be found.

The observation in Béziers implies a local latitude of 43.1° . The tables used to calculate the position of the Sun were most probably those of Ptolemy's *Almagest*.⁵² How Rudolf had access to the *Almagest* is not known. As far as we know, there was no translation available and the early mentions of the book shows better acquaintance with the title than with the contents.⁵³

§12. To construct the azimuths Rudolf gives a method well known from Arabic texts⁵⁴ and, with a small variation, in the text attributed to Messahala.⁵⁵ The meridian line is extended in both directions; the 'hidden' circle is drawn through H , K and Z , the projection of the zenith (found as the last almucantar), the centre A being on the meridian. A horizontal line, perpendicular to the meridian, is drawn through A . On this line lie all the centres of the azimuths: it is the locus of points equidistant from the projection of the zenith and the projection of the opposite point. The left half and right half of the hidden circle are each divided into nine equal parts. Z is joined to each of these by a line and the intersection of this line, produced if

⁵² R. Mercier, 'Astronomical Tables in the Twelfth Century', *Adelard of Bath. An English Scientist and Arabist of the Early Twelfth Century*, ed. C. Burnett, London 1987, 114-115.

⁵³ R. Lorch, 'Some Remarks on the *Almagestum parvum*', *Amphora. Festschrift for Hans Wussing on the Occasion of his 65th Birthday*, eds. S. S. Demidov, M. Folkerts, D. E. Rowe and C. J. Scriba, Basel 1992, 432 n. 76.

⁵⁴ See J. L. Berggren, 'Medieval Islamic Methods for Drawing Azimuth Circles on the Astrolabe', *Centaurus* 34 (1991), 309-44, this on pp. 330ff.

⁵⁵ Berggren, *ibid.*; Chr. Anagnostakis, 'How to Divide the Ecliptic on an Astrolabe', *From Ancient Omens to Statistical Mechanics. Essays on the Exact Sciences Presented to Asger Aaboe*, eds. J. L. Berggren and B. R. Goldstein, Copenhagen 1987. *Acta historica scientiarum naturalium et medicinalium*, vol. 39, this on pp. 140-141.

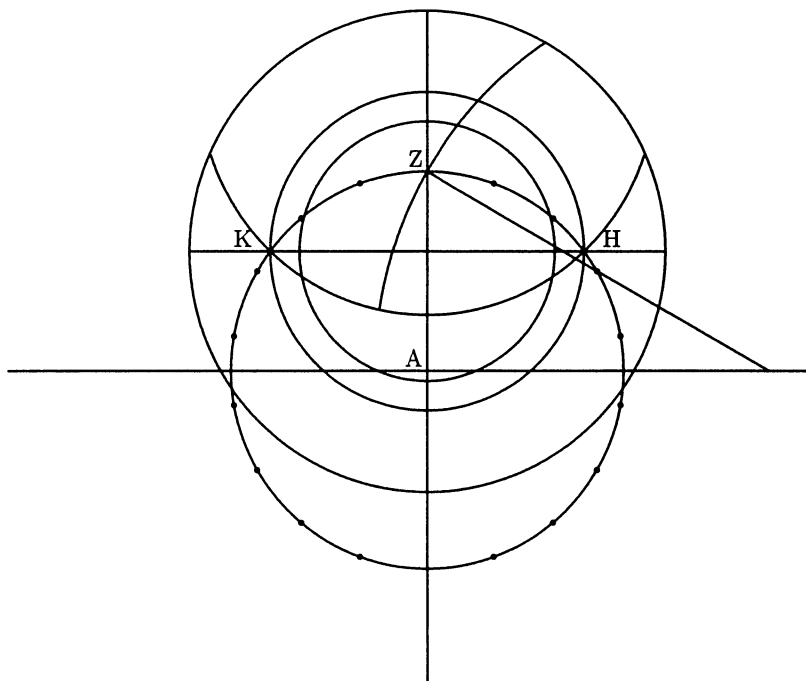


Figure 5a

necessary, with the horizontal line is the centre of the corresponding azimuth. This description accords with the text, but the diagrams in the manuscripts represent the left half of the azimuth-centres as being found by joining the nine divisions of the left half of the hidden circle to the point opposite Z on the hidden circle.

- §13 i. The Sun's *nadir* is found not by taking the opposite point on the zodiac, but by putting the Sun's degree on the horizon in the east and seeing what point on the zodiac lies on the horizon in the west.
- ii. The 'equinoctial colure' must be the 'east-west' line on the back of the astrolabe. The two sets of pin-holes are not mentioned.
- iii. The almucanats were not intended to be labelled with their altitudes, for they are described as being counted.
- iv. Arin is the Ujjayn of Indian astronomy, taken as of zero longitude.⁵⁶

⁵⁶ See e.g. *Alberuni's India*, ed. E. C. Sachau, repr. 1964, 308.

Ujjayn, which became Arin by mis-transliteration, was also sometimes, as here, taken to be of zero latitude.

Comparison with near-contemporary texts

The main characteristics of Rudolf's text are:

1. On the back the months circle is set excentrically within the zodiac circle, with an excentricity of $Cd(2\frac{1}{2}^\circ)$ towards 18° Gemini.
2. The unusual way of dividing the months circle (see above).
3. The spring equinox according to these circles is 16th March.
4. There is no horary quadrant on the back. Only one quadrant (lower right) is recommended for the shadow square.
5. The zodiac on the rete is divided by copying uniform divisions of the outer circle by radial lines.
6. The positions of the stars are found from *mediatio* and *latitudo ab utraque parte*.
7. The limits of the almucanats are found by using an observed latitude (see above).
8. The centres of the azimuths are found by uniformly dividing the circle through the zenith and the intersections of the equator and east-west line.
9. There is no dawn-dusk line.
10. The Sun's *nadir* is found by means of the horizon line.
11. Arin is taken as zero latitude.

When more texts are edited, the above list might prove useful to future scholars. Here we cannot do more than quote a few similarities in other texts. Of the twelfth-century writings relevant to the astrolabe mentioned in the introduction only the *Planisphaerium*, Maslama's notes and appendixes to it, and the astrolabe treatises of Raymond of Marseilles, Johannes Hispalensis and Arianus describe the construction of the instrument. Adelard has a long cosmological introduction and describes several uses of the instrument, but gives no construction.⁵⁷

⁵⁷ Poulle, 'Adelard', 120.

The *Planisphaerium*-Maslama complex appears to have had little influence on Rudolf—though he does cite Hermann's translation of the *Planisphaerium*. There remain Raymond, whose treatise survives only in a single anonymous fifteenth-century copy identified by Poulle from internal evidence⁵⁸, the otherwise unknown Aialdus, whose treatise exists in our manuscript P, ff. 28r-37v, and in MS Cambridge, Jesus College Q.G.29, and Johannes, of whose treatise at least eight manuscripts survive, among others⁵⁹

Fermo, Biblioteca Comunale 85, ff. 99rb-106va, late 13c.

Vatican, Latin 4087, ff. 86v-93v

Oxford, Bodleian, Canonici Misc. 340, ff. 49-53v, 14c.

Johannes takes a leisurely approach, indulging in alternative methods and checks to ensure that some constructions are accurate. Unfortunately the transmission of the text appears not to be simple: there are whole sections in MS Fermo not in MS Vatican and *vice versa* (see below) and in at least one diagram the letters are different; the text in the Bodleian manuscript is followed by a star table and some applications of the instrument; and there appears to be extra material on the fixed stars and on the division of the zodiac in MS Paris, Bibliothèque Nationale, lat. 7293A, used by Poulle.⁶⁰

First, the direction and amount of the excentricity of the zodiac on the back of the instrument. The direction given by Rudolf, towards 18° Gemini, is in accord with Raymond's 17;50° (no amount specified).⁶¹ Aialdus has a concentric circle.⁶² Johannes gives a generous selection.⁶³

postea ponamus super 24 gradus et dimidium signi geminorum vel secundum hoc nostrum tempus, ut mihi videtur, super 26 (...)

At the end of the passage the Bodleian manuscript adds 'nunc vero super 18^m'. None of the values agrees with Rudolf's. The amount of the excentricity according to Johannes is 1/32 of the semi-diameter.⁶⁴ In a section in MS Fermo that is not in the Vatican manuscript, in which the

⁵⁸ Poulle, 'Raymond', 866-867.

⁵⁹ I thank Paul Kunitzsch for giving me access to the Fermo manuscript. We are grateful to Prof. Arno Borst (Konstanz) for sending a copy of it.

⁶⁰ See Poulle, 'Fabrication', n. 42.

⁶¹ Poulle, 'Raymond', 873, n. 3.

⁶² Poulle, 'Fabrication', 118B.

⁶³ MS Fermo, f. 104vb. The Bodleian manuscript, f. 53ra, is essentially the same.

⁶⁴ MS Fermo, f. 104vb. Poulle, 'Fabrication', 118B-119A gives Johannes's value as 1/31 of the diameter and Rudolf's as 1/36. For a discussion of the question in general, see Poulle, 'Peut-on dater les astrolabes médiévaux?', *Revue d'histoire des sciences et de leurs applications* 9 (1956), 301-322, this on pp. 302-304.

discussion begins 'Quidam dicunt', there is a passage that seems to give 1/120 of a semi-diameter in the direction of 25° Gemini.

On the question of the date of the spring equinox⁶⁵ Arialdus says⁶⁶:

Certificabit magister locum solis super initium cuiusque mensis, si sententiam tholomei tenere voluerit, secundum tabulas antiquorum que solem xv die marcii arietem ingredi significant; alioquin, si dictis modernorum adquiescere maluerit, secundum eorum tabulas que solem primum minutum arietis in vicissima secunda die mensis prenominati intrare testantur (...)

This puts Rudolf with Ptolemy. Johannes find that the beginning of Aries occurs on 14th March⁶⁷, but in the extra section in MS Fermo mentioned in the previous paragraph we read:

(...) dicunt etiam equinoctium vernale 16 die marcii esse et hoc est dissentio

As for the division of the zodiac on the rete by copying a simple division of the outer circle, i.e. without applying right ascensions, Raymond and Arialdus also have this method.⁶⁸ According to Poulle, who was working from MS Paris, Bibliothèque Nationale, lat. 7293A, this is also true of Johannes, but in MS Fermo, ff. 103va-b, a different method is presented.

In placing the stars on the rete Raymond and Arialdus describe a method that uses the *mediatio* and the declination. The latter is measured by the intersection of the almucantars on the meridian line and is transferred to the line from the centre to the *mediatio* of the star.⁶⁹ Johannes uses the same coordinates, but gives a graphical method for taking account of declination—a method similar to that found in Arabic writings, e.g. that of al-Sijzi.⁷⁰ In the Vatican manuscript there is an extra section, not in MS Fermo, introduced by

Invenitur in quodam tractatu alio alius modus ponendi stellas fissas in rete,

which describes the *latitudo ab utraque parte* method much as in Rudolf. Since the method is to be found in many other texts—e.g. the *Sententie* and Hermannus Contractus, this unfortunately tells us little about the sources of this passage.

⁶⁵ On this question, see Poulle, 'Peut-on', 304-309.

⁶⁶ MS Cambridge, f. 188r. MS Paris, f. 28v, is essentially the same.

⁶⁷ MS Fermo, f. 105ra

⁶⁸ For Raymond, see Poulle, 'Raymond', 883-884; and for Arialdus, MS Paris, ff. 30v-31r. See also Poulle, 'Fabrication', 122A-B. He gives examples of actual instruments with this fault on p. 126A.

⁶⁹ Poulle, 'Raymond', 884-885; Arialdus in MS Paris, f. 31r.

⁷⁰ MS Istanbul, Ahmed III 3342, ff. 123v-153 and 114r-122v, this on ff. 127v-128r.

For the almucantars all three works have the standard method. In treating the azimuths they are all different. Aerialdus gives no construction for them.⁷¹ Having found the ‘first azimuth’ (the circle called by Rudolfus *occultus*), ‘ (...) pars inferior occulta, superior vero sit manifesta (...) ’, he continues simply,

De ceteris azimuth ideo tractare omisimus quia eis in nullo indigemus.

In Johannes the matter is more complicated. Having constructed the first azimuth, distinguishing, as Aerialdus does, the *manifesta* and the *occulta* parts, he divides the part between the image of the zenith (Q^{72} , Rudolf’s Z) and one of the intersections with the equator (his J , Rudolf’s H) into nine parts and then divides each of the lower (*occulte*) parts into nine⁷³:

(...) dividamus scilicet utrasque <partes> huius circuli superiores, id est a Q in J , per 9 eruntque in unaquaque divisione 10, et similiter in inferiori parte circuli a G in K dividamus per 9 et ab K in J similiter; eritque divisio huius partis inferioris atque maioris, quam occultam fieri iussimus, equalis in divisione et non in quantitate divisionis partis superioris atque minoris quam manifestam fecimus.

Thus the divisions appear to be smaller in the part above the horizon and greater below. Later, after ‘Alius modus’, Johannes describes the method essentially the same as that given by Rudolfus.

It is clear that Rudolf’s text is not similar enough to any of the three—Raymond, Aerialdus and Johannes—for us to suppose a direct connection. Neither the *latitudo ab utraque parte* method for placing the stars nor the *circulus occultus* method of finding the centres of the azimuths seems to be taken from Johannes; the faulty division of the zodiac is to be found in numerous other texts. It therefore seems that Rudolf’s treatise is independent of all of these near-contemporary texts. Equally, it does not seem to have influenced them. It is probable that Rudolf copied the *latitudo ab utraque parte method* for placing the stars on the rete from some Latin writer. His way of drawing the almucantars appears to be unique—perhaps it was his own invention. He must have had some contact with Arabic material because of his azimuth method, but whether he got this from some lost translation or from his association with scholars like Hermann we cannot yet tell.

⁷¹ Poulle, ‘Fabrication’, 120A.

⁷² We follow the lettering of MS Fermo. In this passage the Vatican manuscript has different diagram letters.

⁷³ MS Fermo, f. 102rb. MS Vatican has an alternative passage for ‘et similiter (...) similiter’ and has several smaller divergences; ‘partes’ is taken from this manuscript.

APPENDIX: TWO COMMENTS

At the end of the text in MS T, ff 128v-129r, there are two extra paragraphs, apparently meant as commentary on the beginning of §10. The first is a description of the standard way of finding almucantars and the second is the standard way of finding the local latitude by an observed solar altitude together with tables of declination.

‘Cum ergo latitudinem cuiusque regionis etc.’, ut supra. In hoc capitulo docetur compositio almucantarath hoc modo: factis igitur tribus circulis scilicet equinoctiali et duobus declinationum circulis scilicet cancer et capricornus equinoctialem divide per 4^{or} quadra et postea unumquidque quadrum in 15.⁷⁴ Postea pone regulam⁷⁵ ex una parte super planam lineam occidentalem ubi secat circulum equinoctialem et altera parte⁷⁶ regule pone sursum ita quod tangat 10 punctum quadrantis occidentalis⁷⁷, vero (?) ubi longe extra circulum tetigerit lineam meridionalem puncto signa. Deinde non mota regula ab inferiori loco ponas reliquam regule partem super xi^m punctum eiusdem quadrantis occidentalis et ubi tetigerit lineam meridionalem tunc signa. Sic quoque protraras (?) sequentia puncta eiusdem quadrantis et eodem modo sinistri orientalis et 10 puncta inferioris⁷⁸ quadrantis semper in linea erecta signa ponendo ubi regula ceciderit, et sic habebis 30 signa in linea erecta. Hoc ita facto pone pedem circini alterum in tali loco ut alter pes extrema puncta erecte lineae tangat et sic <facies> primum almucantarath. Deinde vero pone pedem circini ut alter utrimque penultima puncta attingat et sic facies secundum et hac ratione formabis 15 almucantarath secundum latitudinem gotie in biturensi civitate.

Ars inveniendi latitudinem tue vel alterius provincie ubicumque fueris quacumque die volueris quando volueris: sume altitudinem solis per astrolabium et super eundem diem invenias gradum solis in tabulis. Hunc ergo gradum pone super lineam medii celi, que meridionalis dicitur, et ubi solis gradus in reti notatus⁷⁹ predictam lineam tetigerit signa, quia <distancia> ab equinoctiali linea usque ad illum punctum⁸⁰ habebis declinationem solis a equinoctiali circulo sive septentrionalem sive australem. Si ergo sol fuerit in australibus signis 6 ab inicio libre usque ad finem piscis, adde declinationem predictam super altitudinem solis et hec est altitudo solis in arietet et libra in eadem provincia; hanc autem altitudinis minime a 90 et residuum erit latitudo quam queris. Si vero sol fuerit in septentrionalibus signis 6 ab initio arietis

⁷⁴ Here and elsewhere Arabic numerals have Roman numerals of the same value written above them, and *vice versa*.

⁷⁵ regulam] regula MS

⁷⁶ parte] reg- *add. et del.* MS

⁷⁷ i.e. the tenth point of the upper right quadrant, starting from point *H* in Rudolf's diagram, that is, 60° from *H*.

⁷⁸ emisperii *add. et del.* MS

⁷⁹ notatus] notatur MS

⁸⁰ punctum] *seq. ras.*

usque⁸¹ ad finem virginis, minime declinationem solis ab altitudine eiusdem et similiter habebis altitudinem arietis et libre illius loci. Hanc similiter altitudinem minime de 90 et secundum residuum habebis latitudinem quam queris.

⁸¹ usque] *seq. ras.*

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JULIO SAMSÓ

HOROSCOPES AND HISTORY:
IBN ʿAZZŪZ AND HIS RETROSPECTIVE HOROSCOPES RELATED
TO THE BATTLE OF EL SALADO (1340)*

1. *Presentation*

I recently published a preliminary analysis of the *Muwāfiq Zīj* of Abū l-Qāsim ibn [al-Ḥajjāj] ʿAzzūz [al-Qusanṭīnī, d. Constantina 755/1354].¹ In it I summarized the author's prologue in which he states that modern astronomers have been able to establish that the positions of the planets calculated with the *zīj* of Ibn Ishāq (fl. Tunis and Marrakesh ca. 1193-1222)² were in disagreement with observations.³ Ibn ʿAzzūz was himself able to

* The present paper has been prepared within a research programme on 'Astronomical tables and theory in al-Andalus and the Maghrib between the twelfth and the fourteenth centuries', sponsored by the Dirección General de Investigación Científica y Técnica of the Spanish Ministry of Education and Culture. John North's computer programme HOROSC and Benno van Dalen's CALH (for the conversion of dates) have been extensively used. The computer programme for the computation of planetary longitudes with the parameters of the *Muwāfiq Zīj* owes its existence to the joint efforts of Prof. E. S. Kennedy, Dr. Honorino Mielgo and my research graduate student Josep Casulleras. Information about manuscripts was given to me by my research graduate students Mònica Rius and Hamid Berrani. Prof. Aḥmad Shawqī Bīn Bīn, Keeper of the Ḥasaniyya Library, generously offered microfilms of several manuscripts and Prof. Fuat Sezgin sent me information which was not available in Barcelona. A previous draft of this paper was read by Professors E. S. Kennedy, David Pingree, Jan P. Hogendijk and John North (!). My gratitude to all of them.

¹ See J. Samsó, 'Andalusian Astronomy in 14th-Century Fez: *al-Zīj al-Muwāfiq* of Ibn ʿAzzūz al-Qusanṭīnī', in: *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* 11 (1997), 73-110. Our author is mentioned by Ibn Qunfudh al-Qusanṭīnī, *al-Wafayāʾ*, ed. by ʿĀdil Nuwayhiq, Beirut 1978, 358, n. 755. See also ʿA. Nuwayhiq, *Muʿjam al-ʿulam al-Jazāʾir min ʿadl al-Islām ḥattā al-ʿaṣr al-khādir*, Beirut 1980, 231. Ibn Qunfudh states that he was a *faraqī* (expert in partition of inheritances) and a jurist belonging to the school of Mālik b. Anas, and was also proficient in other sciences. He wrote a summary (*mukhtaṣar*) on *Farāʾid* (partition of inheritances) as well as other works. I owe this information to the kindness of Prof. Fuat Sezgin.

² See A. Mestres, 'Maghribi Astronomy in the 13th century: a Description of Manuscript Hyderabad Andra Pradesh State Library 298' in: *From Baghdad to Barcelona. Studies in the Islamic Exact Sciences in Honour of Prof. Juan Vernet*, eds. J. Casulleras and J. Samsó, Barcelona 1996, I, 383-443.

³ See also, on this topic, J. Samsó, 'An Outline of the History of Maghribi Zijes from the end of the Thirteenth Century', *Journal for the History of Astronomy* 29 (1998), 93-102.

establish the existence of such disagreements when he calculated the *tasyīr*⁴ of the signifiers of conjunctions, eclipses and their ascendants to determine the time of events of the past and, especially, the great battle of El Salado [Fahṣ Ṭarīf] which took place in the days of the Mārinid sultan Abū l-Ḥasan ʿAlī, (731/1331-752/1351) in the month of Jumādā I of 741 H. [7 Jumādā I 741/ 30 October 1340]. The times calculated did not correspond to historical reality, and Ibn ʿAzzūz blamed Ibn Ishāq's tables for the mistake. Therefore, in order to correct the divergence, he made observations with an armillary sphere ca. 745/1344: as a result he corrected Ibn Ishāq's mean motion tables and cast again the corresponding horoscopes. This time, he obtained adequate results, once he had made the necessary corrections to the mean motion parameters deduced from observations. He then compiled his new *Muwāfiq Zīj*.

This is quite a peculiar example of an experimental method in which the data are obtained from using astronomical and astrological criteria. Some more information on Ibn ʿAzzūz's techniques can be obtained through an analysis of the materials contained in another of his works: his *Kitāb al-Fuṣūl fī jamʿ al-uṣūl*, of which the second book (*maqāla*) is extant in MS 1110 of the Ḥasaniyya Library in Rabat (RHL hereafter).⁵ Chapter 3 of this same book is also preserved in MS D 2128 of Rabat's General Library (pp. 42-44).⁶ Manuscript RHL 1110 (copy finished the thirteenth of Dhū l-Qaʿda 1281/ 9th April 1865) contains the aforementioned part of Ibn ʿAzzūz's work in fols. 62v-177r. It is quite an extensive astrological work in which the author quotes two other works of his, about which I have no information: the *Madkhal al-ṣināʿa ʿalā madhhab al-jamāʿa* ('Introduction to the Art [of Astrology] according to the opinion of the majority') (fol. 72v), and *Maqālat al-Zuḥal* ('The book of Saturn') (fol. 121v).⁷ The authorities quoted are early and they include a *Kitāb ahl Bābil* ('Book of the people of Babylon', fol.

⁴ See O. Schirmer, 'Tasyīr', in: *Encyclopédie de l'Islam*, first edition, VIII, Paris 1934, 729-733; M. Yano and M. Viladrich, 'Tasyīr Computation of Kūshyār ibn Labbān', *Historia Scientiarum* 41 (1991), 1-16.

⁵ Muḥammad al-ʿArabī al-Khaṭṭābī, *Fahāris al-Khizāna al-Ḥasaniyya. III: al-Riyāḍiyyā, al-Falak wa-Aḥkām al-Nujūm wa l-Jughrāfiyā*, Rabat 1983, 367-368. See also D. Lamrabet, *Introduction à l'Histoire des Mathématiques Maghrébines*, Rabat 1994, 101. I owe a microfilm of this manuscript to the generosity of Prof. Aḥmad Shawqī Bimbīn, Keeper of the Ḥasaniyya Library and to the interest and skill of my postgraduate student Hamid Berrani who spent some time in the Rabat libraries looking for materials on Ibn ʿAzzūz: he is preparing a critical edition with commentary and recomputation of the numerical tables in the *Muwāfiq Zīj*.

⁶ This identification was made by Mónica Rius, during a short stay in Rabat. She provided me with a photocopy of these pages.

⁷ Ibn ʿAzzūz is also the author of a second *zīj*, entitled *al-Zīj al-Kāmil*, which was compiled in 718/1318-19 and does not seem to be extant. The Ṣabīhiyya Library in Salé keeps a *Risāla fī adwār al-nayyirayn* (MS 509/2), which I have been able to read in a photocopy obtained by Hamid Berrani. This latter work is concerned with the 11325-day lunar cycle (cf. Samsó, *Muwāfiq*, 86-88) but it contains no more information than the *Muwāfiq Zīj*.

66v)⁸, Hermes, Ptolemy's *Tetrabiblos* (fol. 64v), and pseudo-Ptolemy's *Centiloquium* (fol. 143v). Among the Islamic authors we find a certain Ibn Tāriq, author of a *Kitāb al-Mithālāt* (fol. 64v, 65r): he is probably the early Abbasid astronomer Ya'qub b. Tāriq, to whom Šā'id al-Andalusī attributes a *Kitāb al-maqālāt fī mawālīd al-khulafā' wa l-mulūk wa qu'ūd man lam yu'raf mawlidu-hu* ('Book of the predictions concerning the nativities of Caliphs and Kings and the accession to the throne of those whose date of birth is unknown')⁹, considered spurious by Pingree.¹⁰ We also have Sa'īd b. 'Alī (Sind b. 'Alī), author of a *Kitāb al-manāḥīs wa l-sa'ādāt* ('On good fortunes and misfortunes') (fol. 64v)¹¹ as well as the famous Abū Ma'shar of whom the *Kitāb al-Mudhākārāt* ('Memorabilia') (fol. 65r), written by his disciple Shādhān, the *Kitāb al-qirānāt* ('On conjunctions') and the *Kitāb al-asrār fī l-mīlāl wa l-duwāl* ('Secrets related to religions and states')—probably another title for the *Kitāb al-qirānāt*—are quoted (fol. 101r). Among more recent authors we have Abū l-'Abbās b. al-Kammād (fl. 1116), author of a *Kitāb mafātiḥ al-asrar al-falakiyya* ('The keys of astronomical secrets') (fol. 66r)¹² and Ibn al-Bannā' al-Marrākushī (1256-1321) (fol. 101r). To these names one should add an otherwise unknown Yaḥyā b. Makir, author of a *Kitāb al-musallaṭayn (?) fī (?) l-tajārib* (fol. 66r).

This second and last book (*al-maqāla al-thāniyya*) of the *Kitāb al-Fuṣūl fī jam' al-uṣūl* ends with an appendix (*khātima*), composed of a single chapter (*faṣl*) in which Ibn 'Azzūz states (fol. 170r) that he is going to cast the horoscope (*nuṣba*) of the [Saturn and Jupiter] conjunction that marks the transfer [*intiqāl*] of those great conjunctions to the triplicity of air, in Libra (1305). He adds that he will also cast a horoscope of the preceding conjunction of the Sun and the Moon (*ijtimā'*). Both remarks are inaccurate: we will see that, in agreement with standard practice, the manuscript reproduces the horoscope of the vernal equinox before the Saturn-Jupiter conjunction (HOROSCOPE 2) and the horoscope of the preceding solar-lunar opposition (HOROSCOPE 1) (fols. 171v-172r). Ibn 'Azzūz comments that the conjunction took place at 17° of the beginning of Libra and, more

⁸ B. L. van der Waerden, 'The "Babylonians" and the "Persians"', in: *Prismata. Festschrift für Willy Hartner*, eds. Y. Maeyama and W. G. Saltzer, Wiesbaden 1977, 431-440.

⁹ Šā'id al-Andalusī, *Ṭabaqāt al-Umam*, ed. Ḥayāt Bū 'Alwān, Beirut 1985, 151; ed. Djulāmriḍā Djamshīdnizād-i Awwal, Tehran 1415/1995, 232 (who notes a variant reading *Kitāb al-Mithālāt*); French transl. by R. Blachère, Paris 1935, 117. A *Kitāb al-Mithālāt* is also attributed to Ya'qub b. Tāriq by Abū Ma'shar: cf. F. Sezgin, *Geschichte des Arabischen Schrifttums*, VII, Leiden 1979, 101-102.

¹⁰ D. Pingree, 'The Fragments of the Works of Ya'qub ibn Tāriq', *Journal of Near Eastern Studies* 27 (1968), 97-125 (see p. 123).

¹¹ Sezgin, *Geschichte des Arabischen Schrifttums*, VII, 119-120.

¹² An extant fragment of this work was published in Catalan translation by my master Juan Vernet, 'Un tractat d'obstetrícia astrològica' in: Vernet, *Estudios sobre historia de la ciencia medieval*, Barcelona-Bellaterra 1979, 273-300.

specifically at 16;4,31° (fol. 173r): in my recomputation,¹³ the true sidereal conjunction took place on 2 Dec. 1305 at 9 p.m. At that time we have (recomputation):

Saturn	196;18,49
Jupiter	196;18,32

Horoscopes 1 and 2 are accompanied by an elaborate commentary (fols. 170r - 177r) of which I will not give a detailed survey in this paper: it is not easy to understand and it requires an edition and commented translation. I will, however, refer to some aspects of that commentary which are concerned with Mathematical Astrology. The subject seems appropriate for an essay written in honour of a scholar like John North, who has taught us how to analyze historical horoscopes and has provided us with a computer programme which is extremely useful for the equalization of the houses.¹⁴

The interesting part of the commentary begins in fol. 172v where Ibn ʿAzzūz reminds the reader that, in the second chapter (*faṣl*) of the same book, he has explained the importance of using a *zīj* as correct as possible and which is based on observations which are near, in time, to the date of the horoscope.¹⁵ The present work is based on the *Muwāfiq Zīj*, which depends on observations made in 745 H [1 Muḥarram 745/ 15 May 1344] which was the year of a conjunction of the two superior planets at the beginning of Aquarius.¹⁶ Although not fully developed, there are references in our text to

¹³ Using a computer programme in which the parameters of the *Muwāfiq zīj* (established in Samsó, *Muwāfiq*) had been introduced. The skeleton of this programme was prepared a few years ago by Prof. E.S. Kennedy for the *Toledan Tables*. Later it was revised by Dr. Honorino Mielgo and, very recently, by Josep Casulleras who has introduced Ibn ʿAzzūz' parameters as well as a few improvements.

¹⁴ J. D. North, *Horoscopes and History*, London 1986. I hope John North will forgive me for plagiarizing the title of his book.

¹⁵ See also fol. 66v: after a long period of time errors are accumulated. The idea of a *zīj* being useful only for a limited period of time appears frequently in western Islamic astronomy beginning with Ibn al-Hā'im (fl. 1205) who insists on the idea of the validity of a *zīj* during a period of about forty years only (see E. Calvo, 'Astronomical Theories Related to the Sun in Ibn al-Hā'im's *al-Zīj al-Kāmil fī l-Ta'ālīm*', in: *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* 12 (1998), 51-111, esp. 75) and, thus, reacts against Ibn al-Kammād who sought to compile a *zīj* valid for all times (*al-Amad ʿalā l-abad*): see J. Chabás and B. R. Goldstein, 'Andalusian Astronomy: *al-Zīj al-Muqtābis* of Ibn al-Kammād', *Archive for History of Exact Sciences* 48 (1994), 1-41.

¹⁶ According to B. Tuckermann, *Planetary, Lunar and Solar Positions. A.D. 2 to A.D. 1649 at Five-day and Ten-day Intervals*, Philadelphia 1964, there was a conjunction of Saturn and Jupiter in Aquarius 19° the 17th Dhū l-Qaʿda 745/ 22 March 1345. Using a computer programme based on Ibn ʿAzzūz' parameters I find a sidereal conjunction seven hours after midday on the 24th February 1345 which actually takes place in the beginning of Aquarius (302;56,27°). This was the conjunction which was interpreted as announcing the Black Death of 1348 and was analysed by Levi ben Gerson: B. R. Goldstein and D. Pingree, 'Levi ben Gerson's Prognostication for the Conjunction of 1345', *Transactions of the American Philosophical Society* (Philadelphia), vol. 80, part 6 (1990).

an horoscope corresponding to the moment of the preceding spring equinox (24 March 1344), which I will call HOROSCOPE 4 (see below §4).

Following his presentation of his materials (fol. 172v) Ibn ʿAzzūz reminds the reader that in the prologue of the aforementioned *zīj* he said that he had tested (*ikhtabarnā*) it, after observation and detailed study (*baʿd al-raṣad wa l-taḥqīq*) with the *tasyīr* of the indicators of the conjunctions, eclipses and anniversaries of the universal *promissors* or *anaires* (*al-qawāfiʿ al-kulliyya*), checking that they were in agreement with symptoms of unexpected events and the times in which those took place. He studied especially the battle of Faḥṣ Ṭarīf/ El Salado which took place in Jumādā I 741 H [actually 7 Jumādā 741/ 30 October 1340], which corresponds to 1651 of Alexander's era. The vernal equinox of the year of the battle was in 739 (complete years), 8 (months), 24 days, 7 (hours) and 14 (minutes) after Hijra, which in the ʿ*ajamī* calendar corresponds to 1650 (years), 5 (months), 24 (days), 7 (hours) and 14 (minutes) after Alexander's epoch.¹⁷ We also have incomplete references to an horoscope cast for that moment, which I will call HOROSCOPE 3 (see below §3).

2. Horoscopes 1 and 2

2.1 The dates of the two horoscopes

Horoscopes 1 and 2 correspond to the last opposition of the Sun and the Moon before the vernal equinox of the year (1305) of the Saturn/ Jupiter conjunction (fol. 171v) and to the vernal equinox of that year (fol. 172r). The former states clearly that it has been cast according to the observation (*raṣad*) of Ibn ʿAzzūz and that it corresponds (fol. 171r) to a date and hour expressed, in *abjad* notation in the following way:

703 - 7 - 12 - 7 - 58 (or 258 instead of 7-58)

It is easy to establish, using the mean planetary longitudes of the horoscope itself, that this corresponds to 703 complete years, 7 months and 13 (not 12) days after the Hijra, although there is disagreement with the actual hour which cannot be 7;58^h after midday. The hour according to the different celestial bodies involved, with the exception of Saturn (5^s 27;26,54^o, which is clearly erroneous for it implies more than 2 days and 12 hours less than the others), should be:

Sun 12;43^h

¹⁷ According to my *Muwāfiq Zīj* computer programme the vernal equinox took place on the 23rd March 1340 A.D./ 24th Ramaḍān 740 H./ 23rd Adhār 1651 of the era of Alexander, between the seventh and the eighth hour after midday. The date is correctly given (with the difference of one day).

Moon 12;31^h
Jupiter 10;58^h
Mars 12;14^h

Since the Moon is the fastest moving of these bodies it seems logical to give priority to the lunar mean position, and the horoscope has been recomputed for 12;30^h after midday of the 14th Sha^cbān 704 H./ 11th March 1305 (JD 2197779). A quick comparison with the recomputed positions obtained with the *Muwāfiq zīj* programme shows the following results for 13 hours after midday of the aforementioned date:

Planet	Mean longitude		Sidereal true longitude	
	Text	Recomputation	Text	Recomputation
Sun	346;31,45	346;32,59	348;23,45	348;24,58
Moon	173;10,53	173;26,48	168;23,45	168;39,14
Saturn	177;26,54	177;31,58	184;6,22	185;8,35
Jupiter	168;20,30	168;20,32	167;56,?	167;56,16
Mars	194;2,52	194;3,55	208;32,21	208;36,2
Venus	346;31,45	346;32,59	8;37,56	8;39,53
Mercury	346;31,45	346;32,59	340;31,57	340;39,55
Asc. node	2[3]2;50 ¹⁸	232;55,2	-	-

HOROSCOPE 1: 11 March 1305, 13^h after midday

As for the second horoscope (vernal equinox), the date and hour appear in the horoscope itself (fol. 172r) as

703 - 7 - 26 (read 25) - 7 - 10, after the Hijra
1615 - ? - 23 (read 22) - 7 - 53, after Alexander's epoch.

The first date corresponds to the 26th of Sha^cbān of 704 H., and the second to the 23th Adhār (which implies that the number of complete months was 5) of 1616 of the Seleucid era and to the 23th of March of 1305 A.D. (JD 2197791). The two dates agree on the hour (7) though not on the minute

¹⁸ 222;50 in the manuscript. The correction is obvious, for the longitude of the descending node is 52;50.

(10/53), and 53^m seems a better reading. The agreement is fairly good with the results obtained with the computer for the aforementioned date at 8 hours after midday:

Planet	Mean longitude		Sidereal true longitude	
	Text	Recomputation	Text	Recomputation
Sun	358;9,59	358;10,18	0;0,1	0;0,18
Moon	328;45,16	328;49,4	334;14,58	334;19,19
Saturn	177;55,[3]8	177;55,38	184;6,22	184;13,44
Jupiter	169;19,23	169;19,19	166;27,9	166;26,31
Mars	200;14,30	200;14,40	208;26,11	207;36,2
Venus	358;9,59	358;10,18	23;7,23	23;7,17
Mercury	358;9,59	358;10,18	2;59,15	2;54,53
Asc. Node	232;17	232;17,32	-	-

HOROSCOPE 2: 23 March 1305, at 8 p.m.

2.2. *The cusp longitudes*

The dates seem to be well established and the planetary longitudes appear to be well computed. The cusp longitudes pose more problems. Thus, for HOROSCOPE 1 (11 March 1305) we have:

I 252;23	VII 72;23
II 291;38	VIII 105;17 (<i>sic!</i>)
III 321;38 (58?)	IX 141;58 (<i>sic!</i> , 38/58)
IV 358;56	X 178;56
V 25;22	XI 201;38 (<i>sic!</i>)
VI 51;29	XII 231;18 (<i>sic!</i> , 29/18)

It is obvious that there are mistakes in the longitudes of the beginnings of houses II-VIII, III-IX, V-XI and VI-XII, for the longitude difference

between opposite houses should be 180° . The following is an attempt to reconstruct the 'correct' values:

I	252;23	VII	72;23
II	2[85];38	VIII	105;[38]
III	321;38	IX	141;[3]8
IV	358;56	X	178;56
V	25;22	XI	20[5];[22]
VI	51;[18]	XII	231;18

Using North's programme *Horosc*¹⁹, an obliquity of the ecliptic of $23;33,30^\circ$ (Ibn 'Azzūz actually uses $23;33^\circ$ in his *zīj*) and a solar longitude of $348;23,45^\circ$, one can establish that (1) the method used for the equalization of the houses is the so-called *standard*; (2) the hour for which the horoscope was cast is $0;38,44^h$ after midnight (which agrees well with the $12;30^h$ after midday established previously; (3) the latitude implied lies between $36;44,58^\circ$ and $37;12,27^\circ$, the mean value being $37;3,40^\circ$. My guess is that this horoscope was cast for latitude $37;10^\circ$, established by Ibn al-Raqqām for Granada: Ibn 'Azzūz takes from Ibn al-Raqqām a table of oblique ascensions for this city calculated for the aforementioned latitude. The differences between the 'corrected' values of the cusp longitudes (I-VI) and the ideal values calculated with North's programme for latitude $37;10^\circ$ are:

I	252;23
II	2[85];38 (0;0,53)
III	321;38 (0;1,41)
IV	358;56 (-0;4,43)
V	25;22 (0;29,25)
VI	51;[18] (1;51,46)

After establishing this hypothesis, a second problem remains. Both horoscopes give the planetary positions twice: in one they appear within the horoscope itself, with the longitudes truncated to degrees or minutes; in the other in the margins of the horoscope, approximated to seconds and with further details about the computation which are explained below in §2.3 and reproduced in the *Appendix*. The planetary positions included in the first horoscope appear in the following way

IV	358;56°	
	Sun	348°
	Mercury	340°
V	25;22°	
	Venus	8;37°
VI	51;29°	
	DescNode	52;50°

¹⁹ North, *Horoscopes and History*, 202-218.

X	178;56°	
	Moon	168;23°
	Jupiter	167°
XI	201;38° (corr. 20[5];[22]°)	
	Mars	[20]8;30°
	Saturn	5 ^s ? (corr. 6 ^s 4°)
XII	231;18°	
	AscNode	222;50°

We can see, therefore, that the longitudes of Mercury, Venus, the Moon, Jupiter and Saturn precede the beginning of the corresponding houses by as much as 20°. John North has analyzed horoscopes in which the beginnings of the houses are replaced by points preceding them by five or eight degrees²⁰, but this horoscope seems to exceed all known limits in this respect. I have no explanation for such an anomaly, except that of an error in the copying of the manuscript.

In the second horoscope (23 March 1305), the houses are:

I	210°	VII	30°
II	242;32°	VIII	62;32°
III	273;14°	IX	93;14°
IV	305;17°	X	125;17°
V	332;12°	XI	152;32°
VI	1;52°	XII	181;52°

There are no inconsistencies here and, again using North's *Horosc*, we can see that the standard method has been used; the hour is 20;30,40^h after midnight. The hour calculated on the basis of the mean planetary longitudes was 7;53^h after midday and the latitude implied lies between 39;6,45° and 40;3,53° (the mean value being 39;46,50°). My guess is, here, that this second horoscope was computed for the latitude of Toledo (latitude 39;54° in the canons of the *Toledan Tables*). The manuscript cusp longitudes of houses I-VI and the differences as regards the ideal values recomputed with North's programme are:

I	210°
II	242;32° (-0;31,8°)
III	273;14° (-0;50°)
IV	305;17° (-0;2,27°)
V	332;12° (-0;14,30°)
VI	1;52° (0;45,56°)

²⁰ North, *Horoscopes and History*, 1, 6, 45, 47, 72, 111, 112.

in which the longitude for the beginning of house VI could easily be corrected into 1;[1]2 (the symbols for 10 and 50 are easy to confuse in Arabic script), the difference, then, being - 0;4,4.

In this second horoscope the planetary positions included in the diagram of the horoscope itself are in the houses in which they should be, with the exception of the Sun:

I	210°	
	AscNode	232;17°
V	332;12°	
	Moon	334;14°
VI	1;52°	
	Mercury	2;59°
	Sun	0;0,0°
	Venus	23;7°
VII	30°	
	DescNode	52;17°
XI	152;32°	
	Jupiter	166;27°
XII	181;52°	
	Saturn	184;6,22°
	Mars	208;26°

Whatever the case may be we have two horoscopes related to the same battle between King Alfonso XI of Castile and Yūsuf I, the Naṣrid sultan of Granada, who had obtained the help of Abū 'l-Ḥasan 'Alī, sultan of the Banī Marīn. There is a certain logic in realizing that Ibn 'Azzūz has cast HOROSCOPE 1 for Granada, the capital of the Banī Naṣr, and HOROSCOPE 2 for Toledo, which he undoubtedly considers to be the capital of the Castilian king. These two are not, however, the only latitudes used by Ibn 'Azzūz in his analysis of the situation. Using HOROSCOPE 2 as his radical horoscope, he directs (*tasyīr*) its ascendent according to four different types of *tasyīr* (see below §5) one of which is the 'middle cycle' (*al-dawr al-awsaṭ*) *tasyīr*, which advances 5° per year and 0;25° per month (fol. 173v). On the basis of a difference in time of 35 solar years and 7 months between 23 March 1305 and 30 October 1340 (the date of the battle) and an ascendent 210° in the radical horoscope, he operates

$$5^{\circ} * 35 + 0;25^{\circ} * 7 = 177;55^{\circ}$$

which he rounds to 178°.

Ibn 'Azzūz adds to this that we should direct (*tasyīr*) the degree of the ascendent expressed in ascensions: if we take the oblique ascension of the first minute of Scorpio (210°, the ascendent of the radical horoscope), add to it 178° (the middle cycle *tasyīr*) and subtract 360° from the result, the result will be an arc of *tasyīr* 34;6,19°.

This implies that the oblique ascension of 210° is $216;6,19^\circ$ and that we should be able to establish the latitude which corresponds to that oblique ascension. Using an obliquity of the ecliptic of $23;33^\circ$, the right ascension of 210° will be:

$$a_0(210^\circ) = \tan^{-1}(\tan \lambda \cos \varepsilon) = 207;53,26^\circ$$

The ascensional difference (e) will be

$$e = a_\phi - a_0 = 216;6,19^\circ - 207;53,26^\circ = 8;12,53^\circ$$

The declination (δ) of 210° being $11;31,26^\circ$, we may write

$$\phi = \tan^{-1}(\sin e / \tan \delta) = \tan^{-1}(\sin 8;12,53^\circ / \tan 11;31,26^\circ) = 35;1,22^\circ$$

Next, he seems to obtain the inverse oblique ascension of $34;6,19^\circ$:

$$a_\phi^{-1}(34;6,19^\circ) = 49;6,28^\circ$$

which is one of the *qawāṭi' al-aṣliyya* (radical promissors).

We can proceed as before to calculate the corresponding latitude:

$$a_\phi(49;6,28^\circ) = 34;6,19^\circ$$

$$a_0(49;6,28^\circ) = \tan^{-1}(\tan \lambda \cos \varepsilon) = \tan^{-1}(\tan 49;6,28^\circ \cos 23;33^\circ) = 46;37,47^\circ$$

$$e = a_\phi - a_0 = 12;31,28^\circ$$

for $\delta(49;6,28^\circ) = 17;34,48^\circ$

$$\phi = \tan^{-1}(\sin e / \tan \delta) = \tan^{-1}(\sin 12;31,28^\circ / \tan 17;34,48^\circ) = 34;23,23^\circ$$

which is not far from the 35° obtained previously. Apparently, Ibn 'Azzūz is using neither of the two latitudes for which he has cast his two horoscopes: $37;10^\circ$ (Granada) and $39;54^\circ$ (Toledo). My guess is that he might be using the latitude of the place of the battle which took place near Tarifa, slightly to the south of Algeciras, for which Arabic sources give latitudes comprised between $35;50^\circ$ and $36;30^\circ$.²¹

2.3. The computation of the planetary longitudes

HOROSCOPES 1 and 2 offer an unusual number of details about the computation of planetary longitudes. For each planet they give its sidereal true longitude but also the *wasaf* (mean longitude), the *markaz thānī* or second *markaz* (the distance of the centre of the epicycle from the corrected planetary apogee, as seen from the centre of the Earth) and the *hiṣṣa thāniyya* or second anomaly (true anomaly measured from the true apogee of the epicycle). The details of the manuscript values as well as the

²¹ E. S. and M. H. Kennedy, *Geographical Coordinates of Localities from Islamic Sources*, Frankfurt 1987, 19.

recomputation made by hand using Ibn ʿAzzūz's *Muwāfiq Zīj* will be found in the *Appendix*: values shown in parentheses () correspond to differences between manuscript values and recomputations, while values shown in square brackets [] are my own recomputations. For each successive step of recomputation I have used the corresponding manuscript values, not the recomputed ones. This means, for example, that I have obtained the mean anomaly of the superior planets from the manuscript values of the mean positions of the Sun and the planet. Also, the

recomputed *second markaz* = manuscript *wasat* - [recomp. corrected apogee] -
[recomp. equation of the centre]

and that the

planet's true longitude = manuscript *second markaz* + [recomp. corrected
apogee] + [recomp. equation of the anomaly]

The results obtained with my recomputations are rarely the same as the manuscript values but they were worth calculating in order to detect gross errors. Such is the case, for example, with the values for the *second markaz* and the second anomaly of Jupiter which have been exchanged in HOROSCOPE 2. In other cases I have given corrected readings of the manuscript values (always inside square brackets and with a footnote which indicates the manuscript actual values) in cases in which the alphanumerical Arabic system of notation (*abjad*) offers enough justification for a correction.

Ibn ʿAzzūz's planetary apogees are sidereal and they are kept at a fixed distance from the sidereal solar apogee. This implies that their positions are displaced at a rate of 0;0,0,2,7,15° per day, which corresponds approximately to the solar apogee's own motion as established by Ibn al-Zarqālluh (d. 1100).²² The same doctrine is followed by Ibn al-Hā'im (fl. 1205), Ibn Ishāq (fl. ca. 1193-1222) as well as by Ibn al-Raqqām (d. 1315) in his *Shāmil zīj*. Ibn al-Bannā' restricted the motion of the solar apogee to the inferior planets and he was followed, in this respect, by Ibn al-Raqqām in his *Qawīm zīj*.²³ In order to establish the position of the planetary apogees in both horoscopes, the obvious starting point is to analyze the information given by the manuscript itself on the solar apogee. Thus, in HOROSCOPE 1, we have:

Wasat of the Sun: 11° 16;31,45° (+0;0,1°)

²² See J. Samsó and E. Millás, 'Ibn al-Bannā', Ibn Ishāq and Ibn al-Zarqālluh's Solar Theory', *Islamic Astronomy and Medieval Spain* (Variorum, Aldershot 1994), no. X.

²³ See J. Samsó and E. Millás, 'The computation of planetary longitudes in the *zīj* of Ibn al-Bannā', *Arabic Sciences and Philosophy* 8 (1998), 259-286.

In the same horoscope the *wasafs* of Venus and Mercury contain mistakes:

Wasaf of Venus: $11^s 11;31,45^o$
Wasaf of Mercury: $11^s 16;38,45^{o24}$

The solar *markaz* of the manuscript is $8^s 27;19,31^o$, from which we can recalculate the longitude of the apogee (λ_A):

$$\lambda_A = 11^s 16;31,45^o - 8^s 27;19,31^o = 2^s 19;12,14^o$$

The radix position of the solar apogee being $2^s 16;44,21^{o25}$ we can establish that the displacement of the solar and the planetary apogees since epoch has been:

$$2^s 19;12,14^o - 2^s 16;44,21^o = 2;27,53^o$$

This result can be checked against the information contained in HOROSCOPE 2, where we have:

Wasaf of the Sun: $11^s 28;29,59^o$
Wasaf of Venus: $11^s 28;9,59^o$
Wasaf of Mercury: $11^s 28;9,7^o$

Here the best reading is the one the manuscript gives for Venus: $11^s 28;9,59^o$ ($-0;2,11^o$). If we use, here also, the solar *markaz* $9^s 8;57,45^o$ we will obtain the same value as in the previous horoscope for the longitude of the solar apogee:

$$\lambda_A = 11^s 28;9,59^o - 9^s 8;57,45^o = 2^s 19;12,14^o$$

We can, therefore, be sure that the displacement of the solar and the planetary apogees since epoch has been $2;27,53^o$. The positions of the planetary apogees, calculated from the radix values given by Ibn ʿAzzūz in his *Muwāfiq Zīj*:

Saturn $7^s 28;38,30^o + 2;27,53^o = 8^s 1;6,23^o$
 Jupiter $5^s 8;21,30^o + 2;27,53^o = 5^s 10;49,23^o$
 Mars $3^s 29;41,30^o + 2;27,53^o = 4^s 2;9,23^o$
 Venus $2^s 16;45,21^o + 2;27,53^o = 2^s 19;13,14^o$
 Mercury $6^s 18;21,30^o + 2;27,53^o = 6^s 20;49,23^o$

The apogee of Venus at epoch in the *Muwāfiq Zīj* ($2^s 16;45,21^o$) derives from the apogees of the Sun and Venus in Ibn al-Kammād's *Muqtabas Zīj*, while Ibn ʿAzzūz's solar apogee ($2^s 16;44,21^o$) seems related to the tradition of Ibn Ishāq, Ibn al-Bannā' and Ibn al-Raqqām ($2^s 16;44,17^o$). I have used this position of Venus's apogee in my recomputation and this gives a better agreement with the manuscript value of the second *markaz* in HOROSCOPE

²⁴ On top of the 38' there is a correction in the manuscript which I read as 31'.

²⁵ Samsó, *Muwāfiq*, 102.

2, while the value of the solar apogee ($2^s 16;44,21^\circ$) is better in the case of HOROSCOPE 1.

2.4. Planetary latitudes.

Surprisingly enough, HOROSCOPE 2 gives the values for the latitudes of the Moon, Saturn, Jupiter, Mars and Venus, though not Mercury. As for HOROSCOPE 1, the latitudes for the Moon and planets do not appear in the manuscript although they are announced and there is an empty space left to inscribe them. The manuscript latitude values in HOROSCOPE 2 are as follows (the differences between the manuscript values and my recomputations are added in parentheses):

Moon	[4];58,28 ⁰²⁶	(0;0,56°)
Saturn	4;1[3],11 ⁰²⁷	(0;0,5°)
Jupiter	2;27,27°	(-0;0,34°)
Mars	0;30,18°	(0;2,45°)
Venus	2;16,8°	(0;2,45°)

I have recomputed the lunar and planetary latitudes using Ibn ʿAzzūz's *Muwāfiq Zīj*. In it, the table for the computation of lunar latitude is Ptolemaic and uses a value of 5° for $\beta_{\max}$.²⁸ The tables for planetary latitudes derive from al-Khwārizmī's *zīj*.²⁹ The latitude is divided into two components, for the first of which (*nisba*) the argument is the second anomaly while for the second (β_2) the argument is the distance to the nearest node. The final formula to compute the latitude of the planet is:

$$\beta = \text{nisba} * \beta_2$$

It is easy to see that the values of β_2 are identical to those of the corresponding function in al-Khwārizmī's *zīj*. As for the *nisba*, Ibn ʿAzzūz's function is the reciprocal of the corresponding one in al-Khwārizmī (β_1):

$$\text{nisba} = 60 / \beta_1$$

which agrees with al-Khwārizmī's final formula for planetary latitude, which is:

$$\beta = \beta_2 / \beta_1$$

²⁶ 1° in the manuscript.

²⁷ $18'$ in the manuscript.

²⁸ *Muwāfiq Zīj* MS Rabat Ḥasaniyya Library (RHL) 8772, p. 59 and Rabat General Library (RGL) D2461, p. 398.

²⁹ *Muwāfiq Zīj* RHL p. 83, RGL p. 411 (Saturn); RHL p. 88, RGL p. 414 (Jupiter); RHL p. 93, RGL p. 418 (Mars); RHL p. 97, RGL p. 422 (Venus); RGL p. 426 (Mercury); this latter table is missing in RHL. See H. Suter, *Die astronomischen Tafeln des Muhammed ibn Mūsā al-Khwārizmī in der Bearbeitung des Maslama ibn Aḥmed al-Madrī fī und der latein. Uebersetzung des Athelhard von Bath*, Kobenhavn 1914, 138-167.

Ibn ʿAzzūz's planetary nodes are kept at a fixed distance from the sidereal 'corrected' apogees (*al-awj al-muʿaddal*) which implies, obviously, that they are also affected by the motion of the apogees. The distances mentioned in the *Muwāfiq Zīj* are:

Saturn	140°
Jupiter	70°
Mars	90°
Venus	0°
Mercury	180°

The distances for the superior planets are the same as those of the *Almagest* (XIII,6). Ptolemy, however, considers that the nodal line for Mercury and Venus is perpendicular to their apsidal line and that the distances between the apogee and the node are 90° for Venus and -90° for Mercury. We have here a clear disagreement with the distances stated by Ibn ʿAzzūz who, in the case of Venus, states very clearly *Wa-amma jawzahar al-Zuhra, fa-mawḍiʿ awji-hā al-muʿaddal huwa jawzaharu-hā* ('As for the node of Venus, the position of its corrected apogee is its node'). We have no way to check the nodal distance for the case of Mercury, because no latitude is given for that planet in our horoscope. In the case of Venus, however, a latitude of 2;13,23°, which is not far from the 2;16,8° of the text, has been recomputed by using an argument of latitude of

$$79;13,14^{\circ} (\text{apogee}) - 90^{\circ} = 349;13,14^{\circ}$$

There seems, therefore, to be a mistake in the distances between the nodes and the apogees for the inferior planets of the *Muwāfiq Zīj*.

3. Horoscope 3: the spring equinox of the year of the battle of El Salado (23 March 1340)

In fol. 173v-174r we find a reference to the horoscope of that spring equinox: the ascendent was 196;50°; Mars was in Taurus 13° in the second house from the Sun and in the VIII house of the horoscope: the recomputed longitude of Mars is 43;4,46° and, the ascendent being 196;50°, for any latitude comprised between 33;40° (Fez) and 39;54° (Toledo), house VIII will begin at about 49°, very near to the position of Mars and the Sun will be in house VI, approximately two houses away from Mars. The text goes on to say that Venus (recomputed position 7;27,36°) is in its *wabāl* (detriment), which should be Scorpio during the night and Aries in daytime. Here Ibn ʿAzzūz seems to have in mind Aries, in spite of the fact that the hour of the horoscope is roughly 7 p.m., which would be after sunset. Venus is in house VI (beginning at about 345°).

4. Horoscope 4: the spring equinox of 1344 (24 March 1344)

In fol. 174r Ibn ʿAzzūz refers to the horoscope of the spring equinox of the year in which he made his observations: the event took place 743 [complete years], 10 [complete months], 9 [complete days], 7 [hours], 56 [minutes] after epoch. The equivalent Islamic date is, then, 10th Dhu l-Qaʿda 744/ 24 March 1344 A.D. and the information given in our text for the planetary positions (inside square brackets the computer recalculations for 8 p.m.) is:

Saturn	Capricorn 25°	[294;49,0°]
Moon	Cancer 24°	[113;11,39°]
Mars	Gemini 13°	[72;48,24°]

The text adds that the ascendent is Libra 27;45° and that Mars is in house VIII (for any latitude comprised between 33;40° (Fez) and 39;54° (Toledo), house VIII will begin at about 60°). The indicators predict sudden death, illness in the throat and epidemic diseases. He then refers to the Saturn-Jupiter conjunction of 1345 which took place in Aquarius 3° (recomputed 302;56,27°), and indicated earthquakes and destruction of houses. The moment of the conjunction is also given as 744 [years], 9 [months], 21 [days] and 2 [hours] (?) after epoch (22nd Shawwāl 745 H./25th February 1345 A.D.³⁰). The end of the conjunction took place in the same year 10 m., 2 d., 13 h., 14 m. (3rd Dhu l-Qaʿda 745 H./7th March 1345 A.D.). I do not understand the criteria used by Ibn ʿAzzūz to fix the end of the conjunction: the recomputed values of the longitudes of Saturn (304;10,1°) and Jupiter (305;23,46°) are more than 1° apart on 7 March 1345, but the same happens on the 6th and the 5th of March.

5. The different kinds of *tasyīr* used by Ibn ʿAzzūz

The ascendent in HOROSCOPE 2 (210°) is his significator (*dalīl*, usually called *al-mutaqaddim* or *al-haylaj*) and the period of time which corresponds to the *tasyīr* (35 solar years and 7 months between the spring equinox of year 1305 and the date of the battle, 30 October 1340) is known. Ibn ʿAzzūz seeks to calculate which are the promissors (the planets, stars, or points of the ecliptic which were responsible for the catastrophe), according to the different kinds of *tasyīr* he uses. The promissor is usually called *al-thānī* (the second) or *al-qāṭiʿ* (cutter), which corresponds to the Castilian-Alfonsine term *taiador*.³¹ With the sole exception of his use of oblique

³⁰ As we have seen in §1, the recomputed conjunction took place one day earlier: 24 February 1345.

³¹ M. Viladrich and R. Martí, 'Sobre el *Libro dell Ataçir* de los *Libros del Saber de Astronomía* de Alfonso X el Sabio', in: *Nuevos Estudios sobre Astronomía Española en el Siglo de Alfonso X*, ed. J. Vernet, Barcelona 1983, 75-100.

ascensions in the calculation of the 'middle cycle' (*al-dawr al-awsaṭ*) *tasyīr*, the rest of the techniques used by Ibn ʿAzzūz are extremely simple, being based on simple progressions on the ecliptic.³² Thus, our author calculates four different kinds of *tasyīr* in agreement with his earlier explanation in the fourth chapter (*faṣl*) of this same book (fols. 124r and v):

5.1 'Small cycle' (*al-dawr al-aṣḡar*): from the ascendent of the radical horoscope, with a rate of motion of 30° per year, 2;30° per month and 0;5° per day. It is also called *burj al-intihā'* and it corresponds to the 'small world *intihā'*' of Eastern astrologers.³³ The amount (fol. 172v) will be:

$$210^{\circ} + 35 \text{ years} * 30 + 2;30^{\circ} * 7 \text{ months} = 3 * 360^{\circ} + 180^{\circ} + 17;30^{\circ}$$

The *intihā'* in the moment of the battle will take place at 17° of the beginning of Libra (fol. 173r), which is also the degree of the true Saturn-Jupiter conjunction (see above §1) and the degree of the ascendent of the spring equinox of the year of the battle (1340) (see above §3).

5.2 'Middle cycle' (*al-dawr al-awsaṭ*) which corresponds to a period of 72 years. It is also called *al-tadbīr al-firdāwī*. It moves 5° per year, 0;25° per month and 0;0,50° per day. See above §2.2. For the spring equinox of the year of the battle we have:

$$210^{\circ} + 5^{\circ} * 35 = 360^{\circ} + 25^{\circ}$$

and, for the actual date of the battle:

$$25^{\circ} + 0;25^{\circ} * 7 = 27;55^{\circ}$$

³² J. P. Hogendijk ('Progressions, Rays and Houses in Medieval Islamic Astrology: A Mathematical Classification', paper presented at the Dibner Institute Conference *New Perspectives on Science in Medieval Islam*, held in Cambridge, Mass. in November 6-8, 1998) classifies the different methods for the division of houses, *tasyīr* and projection of rays and includes this simple ecliptical method among those used for the projection of rays but not for the *tasyīr*. The oblique ascension method for the *tasyīr* is mentioned by Ptolemy in the *Tetrabiblos*: he says that it is the usual system but that it is correct only if the celestial body or the point of the ecliptic is on the Eastern horizon. On the other hand, in fol. 122r of this same work, Ibn ʿAzzūz states that, for the calculation of the *tasyīr*, the correct method is that of Ptolemy and Hermes and that it is the method followed by modern authors in spite of its approximate character. Ptolemy describes, in his *Tetrabiblos*, the use of the 'position semicircle'—whose endpoints are the North and the South points of the horizon—and the equator for the *tasyīr* (equatorial method), although he actually uses an approximation (Hour Line method). The equatorial method is also ascribed to Hermes by Andalusian sources, and this seems to be the reason for Ibn ʿAzzūz' attribution of the same method—which he apparently does not use—to Ptolemy and Hermes.

³³ E. S. Kennedy, 'The World-Year Concept in Islamic Astrology', in: Kennedy et al., *Studies in the Islamic Exact Sciences*, Beirut 1983, 351-371 (see 356); D. Pingree, *The Thousands of Abū Maʿshar*, London 1968, 60, 65.

Ibn ʿAzzūz looks here for one of the *qawāʿi* ʿ (promissors), which he identifies with the lot of the kingdom (*sahm al-mulk*), which should be taken from Saturn to the Sun and then subtracted from the ascendent. In HOROSCOPE 2 Saturn's longitude is 184°, the Sun is at Aries 0° and the ascendent is 210°. Apparently he implies

$$210^{\circ} - 184^{\circ} = 26^{\circ}$$

5.3 A *tasyīr* of one degree per year. This cycle corresponds to the 'small world *tasyīr*' or 'small *qisma*' of Eastern astrologers³⁴, although they refer the motion to the equator rather than the ecliptic: in 35 years we have 35° which are added to the 210° of the ascendent:

$$210^{\circ} + 35^{\circ} = 245^{\circ}$$

245° is the longitude of the star *Shawlat al-ʿAqrab* which is one of the *qawāʿi* ʿ (promissors). *Shawlat al-ʿAqrab* is λ Sco, for which the star-catalogue of the *Almagest* gives a longitude of 237;30°. This star does not appear in the star table of the *Muwāʿiḳ Zīj*: all the stars in that table have Ptolemaic longitudes increased by 6;48°. Ibn ʿAzzūz, therefore, should assume a longitude for that star of

$$237;30^{\circ} + 6;48^{\circ} = 244;18^{\circ}$$

To this Ibn ʿAzzūz adds that the *sahm al-saʿd* (usually *sahm al-saʿāda*, *pars Fortunae*) is 184;14°. This can be confirmed in HOROSCOPE 2 in which we have:

- Longitude of the Sun:	0;0°
- Longitude of the Moon:	334;14°
- Ascendent:	210°

The *pars Fortunae* should be:

$$334;14^{\circ} + 210^{\circ} - 360^{\circ} = 184;14^{\circ}$$

This coincides with the position of Saturn (184;6,22°). The *pars Fortunae* is the *sahm al-naḥs* (Lot of misfortune).

5.4 The 'great cycle' (*al-dawr al-akbar*) or *al-tasyīr al-ṭabfī*, which lasts 120 years, considered to be the natural (*ṭabfī*) duration of human life. The rate of motion is, thus, 3° per year, 0;15° per month and 0;0,30° per day. We have, then, for the date of the spring equinox (fol. 173v):

$$210^{\circ} + 35 \times 3^{\circ} = 315^{\circ}$$

³⁴ Kennedy, 'World year', 355; Pingree, *Thousands*, 59, 65.

and with these 315° we reach the star *al-Ḥūt al-Janūbī* in Aquarius, which is one of the *qawāḥ*^c (promissors). Ibn ʿAzzūz probably refers to *Fam al-Ḥūt al-Janūbī* (α *Piscis Austrinus*) the longitude of which, in the *Almagest*, is 307° . For our author, its longitude should be:

$$307^\circ + 6;48^\circ = 313;48^\circ$$

5.5 The *tasyr* of the conjunctions (*tasyr al-qirānā*)

Ibn ʿAzzūz states that he has explained the *tasyr al-qirānā* in the fifth chapter (*faṣl*) of this same book, but I cannot find any such explanation. He says that we should calculate where the conjunction of the change of triplicity takes place [at Libra 16° , which belongs to the airy triplicity], and obtain its distance from the triplicity of water [i.e from the beginning of Scorpio]. The distance from Scorpio is $1[4]^\circ$ [= $210^\circ - 196^\circ$]. The conjunction will stay in Libra, between the two changes of triplicity, 239 years.³⁵ We divide 360° by 239 years, the result being $1;30,23^\circ$ ($1;50,28^\circ$ according to the manuscript, but the mistake is easy to explain in *abjad* notation). The arc of the *tasyr* in 35 years will be:

$$1;30,23^\circ * 35 = [1^\circ] 22;43^\circ$$

The *tasyr* will attain $22;43^\circ$ of Sagittarius [$210^\circ + 52;43^\circ = 262;43^\circ$], which is the longitude of the star *ʿAyn al-Ramī*, which will be one of the *qawāḥ*^c. *ʿAyn al-Ramī* is $\nu^1 + \nu^2$ Sagitt., for which the *Almagest* gives a longitude of $255;10^\circ$. For Ibn ʿAzzūz the longitude should be

$$255;10^\circ + 6;48^\circ = 261;58^\circ$$

6. Conclusions

There is no doubt that HOROSCOPES 1 and 2 were cast by Ibn ʿAzzūz retrospectively in order to check the validity of the new mean motion tables of his *Muwāfiq Zīj*. It is also clear that he was mainly interested in HOROSCOPE 2 (although he occasionally used horoscopes 1, 3 and 4). HOROSCOPE 2 is the radix of all his *tasyr* computations and it has been cast far more carefully than HOROSCOPE 1. I do not know, however, whether the first horoscopes (not extant, apparently) he cast in relation to the battle of El Salado, in which he used mean motion tables derived from the tradition of Ibn Ishāq, were also retrospective, and to what extent Ibn ʿAzzūz had cast a horoscope before the battle because he had been asked to do so by

³⁵ In fol. 65v, Ibn ʿAzzūz says that a conjunction will stay in the same triplicity 13 consecutive times in ca. 250 years. 239 years seems more accurate: using the *Muwāfiq* computer programme I find that the next Saturn-Jupiter conjunction with change of triplicity ($219;46,41^\circ$) takes place on 20 August 1544, at about 16 hours after midday.

the circles of power surrounding *amīr* Abū l-Ḥasan ʿAlī. The problem is of particular interest, since the scholar Ibn Marzūq (1310-1379), who fought in the battle, wrote an hagiographic portrait of Abū l-Ḥasan, one chapter of which is dedicated specifically to Abū l-Ḥasan's rejection of Astrology—something that was a consequence of his extreme orthodoxy.³⁶ The question remains open but, if the answer was affirmative, it would not be the first instance in which an Islamic ruler adopted an official attitude of rejection while at the same time employing a private astrologer to inform him about the development of future events of interest to him: such is the case of the Andalusian dictator al-Manṣūr ibn Abī ʿĀmir (981-1002) who was responsible for the selective burning of the books of the library of al-Ḥakam II (961-976)—including the books on Astrology—but who nevertheless employed an astrologer to cast the horoscope of the birth of his son, ʿAbd al-Malik al-Muzaffar.³⁷

³⁶ See Muḥammad ibn Marzuq al-Tilimsānī, *al-Musnad al-ṣaḥīḥ al-ḥasan fī ma'āthir wa-maḥāsīn mawlā-nā Abī l-Ḥasan*, ed. M. J. Viguera, Algiers 1981, 438-444; Spanish translation and commentary by M. J. Viguera, *El Musnad: hechos memorables de Abū l-Ḥasan, sultán de los Benimerines*, Madrid 1977, 361-366.

³⁷ J. Samsó, *Las Ciencias de los Antiguos en al-Andalus*, Madrid 1992, 78.

APPENDIX
THE COMPUTATION OF PLANETARY LONGITUDES
IN HOROSCOPES 1 AND 2

Planet	mean long.	markaz	eq. cn.	markaz 2	mean an.	anom. 2	eq. anom.	true long.
Sun	346;31,45 (0;0,1)	267;19,31	1;52	-	-	-	-	348;23,45
Moon	173;10,53 (0;0,23)	Double elong. [13;18,16]	[1;57,44]	-	[110;51]	112;49,2 (0;0,18)	[-4;47]	168;23,45 (-0;0,8)
Saturn	177;26,54 (-0;5,1)	[296;20,31]	[5;42,58]	302;[3],26 ³⁸ (-0;0,3)	[169;4,51]	163;21,56 (0;0,3)	[1;56,14]	185;4,27 (-0;1,39)
Jupiter	168;20,30 (-0;0,19)	[7;31,7]	[-0;39,36]	6;52,27 (0;0,56)	[178;11,15]	178;50,55 (0;0,4)	[0;15,59]	167;56,7 (rc. 167;56,53)
Mars	194;2,52 (-0;0,21)	[71;53,29]	[-10;28,34]	61;25,51 (0;0,56)	[152;28,53]	162;57,31 (0;0,4)	[25;3,1]	208;32,21 (-0;4,58)
Venus	34[6];31,45 ³⁹ (0;0,1)	[267;18,31]	[1;59]	269;[1]8,31 ⁴⁰ (0;1)	[50;41,20]	48;[4]2,21 ⁴¹ (0;0,1)	[20;7,16]	8;37,56 (-0;0,5)
Mercury	346;3[1],45 ⁴² (0;0,1)	[145;42,22]	[-1;44,53]	143;58,32 (0;1,3)	[343;22,59]	345;7,56 (0;0,4)	[-4;13,27]	340;31,57 (-0;1,28)

HOROSCOPE 1 (11 March 1305) (Unit: degree)

³⁸ The number corresponding to the minutes is doubtful in the manuscript. it may be a 3 or a 4.

³⁹ MS 11° 11;31,45°.

⁴⁰ 38' in the manuscript.

⁴¹ 12' in the manuscript.

⁴² MS 11° 16;38,45°.

Planet	mean long.	markaz	eq. cn.	markaz 2	mean an.	anom. 2	eq. anom.	true long.
Sun	358;[9],59 ⁴³ (0;2,11)	278;57,45	1;50,2	-	-	-	-	0;0,1
Moon	328;45,16 (0;0,4)	Double elong. [301;10,34]	[8;24,57]	-	[265;6,59]	256;42,22 (0;0,20)	[5;29,39]	334;14,58 (0;0,3)
Saturn	177;55;[3]8 ⁴⁴ (0;0,1)	[296,49,15]	[5;41,32]	302;38,46 (0;7)	[180;19,21]	17[4];26,52 ⁴⁵ (-0;10,57)	[0;40,30]	184;6,22 (-0;11,18)
Jupiter	169;19,23 (-0;0,19)	[8;30]	[-0;44,30]	7;46,15 ⁴⁶ (0;0,45)	[188;50,36]	189;35,21 ⁴⁷ (0;0,15)	[-2;7,40]	166;27,9 (-0;0,4)
Mars	200;14,30 (-0;0,8)	[78;5,7]	[-10;53,20]	67;12,43 (0;0,56)	[157;55,29]	168;49,43 (0;0,54)	[18;36,21]	208;26,11 (0;28,40)
Venus	358;9,59 (0;2,11)	[278;57,45]	[1;58]	28[0];54,44 ⁴⁸ (-0;0,1)	[57;58,7]	56;1,7 (0;1)	[23;0,29]	23;7,23 (0;1,5)
Mercury	358;9;[59] ⁴⁹ (0;2,11)	[157;20,36]	[-1;10,58]	156;10,41 (0;1,3)	[20;3,56]	2[1];14,33 ⁵⁰ (-0;0,21)	[6;0,4]	2;59,15 (0;0,10)

HOROSCOPE 2 (23 March 1305) (Unit: degree)

⁴³ 20' in the manuscript. 9' corresponds to Venus's mean longitude.

⁴⁴ 18' in the manuscript.

⁴⁵ 177° in the manuscript.

⁴⁶ This is the manuscript value for the second anomaly.

⁴⁷ This is the manuscript value for the second *markaz*.

⁴⁸ In the manuscript I read 9° 7;54,44°.

⁴⁹ 7' in the manuscript.

⁵⁰ 20° in the manuscript.

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FRANCIS MADDISON AND ANTHONY TURNER

THE NAMES AND FACES OF THE HOURS*

To identify portions of the day for communal use by an arbitrary and invariable numerical grid imposed upon the nychthemeron, the time unit defined by two solar transits across the same meridian, was a development made by a sophisticated society in historical time. This development may be located in John North's favourite fourteenth century in Europe and it is a development about which he has had something to say.¹ But if the introduction of this equal hour reckoning, as it is called, into social use can thus be temporally located with relative precision, the origins of the system which it replaced—unequal hour reckoning—are rather more difficult to determine. To divide up the period of daylight and the period of night separately seems, for the activities of everyday life, the most natural way of operating. The system is of great antiquity and it offers the advantage of maximum exploitation of natural light in ages innocent of artificial illuminants. For the activities of everyday life in early agrarian societies an abstract numerical grid, even a variable one, was not necessary and may even not have been conceptually possible. The origins of a numerical time or hour division and of ways of distinguishing different periods within the unequal spans of day and night are therefore not coterminous. Locating oneself in temporal space by expressions referring to some daily activity such as the yoking or unyoking of oxen, eating, the watering of livestock or to some natural, easily remarked event such as the changing position of the Sun, the nature of the daylight, 'the cry of the partridge' or 'the stirring of flies' has a long and rich history,² one which continued in parallel with numerical hour-counting and probably preceded it. Counting the hours however reaches at least as far back as the third millennium BC in Egypt and may have originated there. More important in the present context is that as they counted the hours, the Egyptians also designated them.

* We are greatly indebted to Dr Emilie Savage-Smith, Wellcome Unit for the History of Medicine, Oxford, for assistance with the Greek and Arabic hour-names and discussing the entire paper with us.

¹ Chaucer's *Universe*, Oxford 1988, 76ff.

² M. P. Nilsson, *Primitive Time-reckoning. A Study in the Origins and first development of the Art of counting time among the primitive and early Culture Peoples*, Lund 1920, who offers numerous examples in the first chapter of his study.

The Egyptian invention of a system for dividing up the night into a series of equal parts³ originated in the need of priests to be able, mentally and ritually, to accompany the Sun-god *Re* along the different stages of his dangerous nightly journey through the dark regions, the abode of the dead, of gods and spirits. This journey, which was seen spiritually as being equivalent to that of the soul after death, offers many variants in the different versions in which it is recounted. Essentially, however, during the day the Sun-God *Re*, in his solar ship traverses the outside of the belly of the goddess *Nut* which, stretched out over the earth, forms the sky. During this period it was essential that the various daily rites should be performed at the correct times.⁴ At nightfall *Re* enters the goddess's mouth (placed on the western horizon). Thence he travels through twelve staging places, each equivalent to one unequal hour, to be reborn from her lower parts at dawn of the next day.⁵ Each of the God's twelve ports of call, where he regulates the life of the underworld, is identified by the name of the god or goddess governing the hour (Table 1), by the part of the anatomy of *Nut* wherein *Re* finds himself (Table 2), by the name of an identifying decanal star,⁶ or by a word or phrase descriptive of the hour.⁷

³ M. Clagett, *Ancient Egyptian Science, a source Book. Volume II Calendars, Clocks, and Astronomy*, Philadelphia 1995, 48ff citing the earlier literature. The locus classicus lying behind Clagett's work is of course that of O. Neugebauer and R. A. Parker, *Egyptian Astronomical Texts*, 3 vols, Providence-London, 1960-1969. Division of the night into equal parts had already begun by the 24th century BC. It seems to have preceeded the equivalent division of the day.

⁴ S. Sauneron, 'Le prêtre astronome du Temple d'Esna', *Kémi. Revue de philologie et d'archéologie Egyptiennes et Coptes* 15 (1959), 36-41 speaks of a 'préoccupation' with the exact determination of the hours (p. 36). Elsewhere he notes that astronomical knowledge served the priests 'essentially, in a practical manner, to determine the hour of the rites which rigorously divided the various elements of the cult', *Les Prêtres de l'ancien Égypte* (1957), Paris 1998, 174, which work describes the general context of priestly activity in Egypt.

⁵ The clearest text describing all this is probably 'The Book of Amaduat' (Amdat) (alternatively entitled 'the Book of what is in the Netherworld'), translated in M. Clagett, *Ancient Egyptian Science, a source Book. Volume I, Knowledge and Order*, Philadelphia 1992, 491-510 with commentary and introduction 471-490. For an even more complex picture compare that given in 'The Book of Nut' as presented in Clagett ii, 357-392. The texts painted on the corridors of the tomb of Ramses VI are excellently presented, commented, transcribed and translated by A. Piankoff and E. Drioton, *Le livre du jour et de la nuit*, Cairo 1942 (Institut français d'Archéologie orientale, Bibliothèque d'Etude xiii).

⁶ Examples of such hour-indicating names can be seen in the 'Book of Nut', translated in Clagett, ii, 371-383. The names of the stars, and the corresponding body positions given for them, noted for identifying the sequence of hours in the Rammeside star clocks could also have given rise to hour names. For the star clock text in translation see Clagett, ii, 405-456.

⁷ E.g. the description of the 12th night hour in the Hete coffin text at Edfu as *nb sp tnm kk* (mistress of light), the 1st day hour as *Nna* or *bn-t* (goddess of sunrise), and the 12th day hour as *xnm(t) nx* (reunion with life). H. Brugsch, *Matériaux pour servir à la reconstruction du calendrier des anciens égyptiens*, Leipzig 1864.

Table 1

Names of Hour-goddesses from the 'Book of Amduat', that is the Book of what is in the Netherworld. From Claggett, *Ancient Egyptian Science* i, 491-507.

- 1 She who cleaves the Brows of the enemies of Re
- 2 The Learned One, She Who Protects her Lord
- 3 She who Cuts Up Souls
- 4 She Whose Power Is Great
- 5 She Who Guides within Her Bark...
- 6 Mesprit⁸, She Who Gives the Correct (Way)
- 7 She Who Repulses the Serpent Hiu and Cuts Off the Head of the Serpent Neha her...
- 8 Lady of the Deep Night
- 9 She Who Adores, She Who Protects Her Lord
- 10 The Raging One Who Slaughters Those Left Behind
- 11 Starry One, Mistress of the Bark, She Who Repulses the Rebel at His Appearances
- 12 She Who Sees the Beauty of Re

Table 2

Hourly positions of *Re* as he traverses the body of *Nut*. From the shadow clock text in the Cenotaph of Seti I at Abydos. From: H. Frankfort, *The Cenotaph of Seti I at Abydos*, 2 vols, London 1930.

1	ḏrt	hand
2	spt	lip
3	nḥdt	tooth
4	ḥtt	throat
5	šnbt	breast
6	...t...	...
7	mnt	...
8	mndr	gall bladder
9	mḥtw.s	intestines
10	k't	vulva
11	...	...
12	mnt	thigh

Such descriptive terms can very easily become nominative. The hour of *ḏrt*, the hand (= first hour of the night) slides into 'hand hour', and when a similar process occurs with the names of the ruling gods and goddesses, not only does the name of the deity become that of the hour, but the hour may also become personified by it. Table 3 offers a composite list of hour ruling deity names,⁹ three of which appear simply as names among the hours marked on the horizontal sun-dial from Sais of c. 1000 (Table 4).

⁸ I.e. 'Arrival'.

⁹ We are grateful to Sarah Symons, Department of Mathematics and Computing, University of Leicester for drawing up this list (in modernised transliteration) from E. A. Wallis Budge, *An Egyptian Hieroglyphic Dictionary*, 2 vols, London 1920 (repr. London 1978). It should be compared with that of H. Brugsch, *Thesaurus Inscriptionum Aegyptica-*

Table 3

Composite list of the names of deities ruling the hours prepared by Sarah Symons, Leicester

	Goddesses of the hours of the day	Goddesses of the hours of the night	Gods of the hours of the night
1 st		186b <i>wšm-h't-hftw=s</i> 362b <i>nbt hrw</i> 365b <i>nbt tln</i>	
2 nd	563a <i>hrsk-kk</i> 565b <i>hsr-kk</i> 699a <i>sšmt</i>		785b <i>k3 t3wy</i>
3 rd	289a <i>mk-nbst</i> 625b <i>sk3-nw-b3w-ptr-hh</i>	614a <i>šhrt-dw</i>	871b <i>dw3-mwt=f</i>
4 th	10a <i>3sbyt</i>	109b <i>ʿ3t-šfyt</i> 174a <i>wrt-šft</i>	272b <i>m3ʿ-hr</i>
5 th	96a <i>lgrt</i> 392b <i>nsbt</i>	359b <i>nbt-ʿnh</i>	503b <i>hr-hr-w3d=f</i>
6 th	134a <i>ʿhʿyt</i>	912b <i>qsr-ššt3t</i>	67b <i>lr-m-ʿw3</i> 703b <i>sk-r</i>
7 th		498b <i>hr-tp-lh(-hr-nb-st)</i> 565a <i>hsf-h3l-hsk-nh3-hr</i>	506a <i>hr-dw3t</i>
8 th		125b <i>ʿnh-m-nst</i> 314b <i>mrt-nst</i>	67b? <i>lr-n-ds=f</i>
9 th	81a <i>3st-m-nb-ʿnh</i> 912b <i>qsr-ššt3t</i>	364a <i>nbt snʿt</i>	59a <i>in-mwt=f</i>
10 th	709a <i>stl-lrw</i>	289a <i>mk-nbst</i>	362b <i>nb hp-nʿrw</i>
11 th	371b 392b <i>nsb-hpr-lrw?</i> 676b <i>snb-hprw</i>	286b <i>mk-hšhmwyt</i> 565a <i>hsf-hmyt</i> 565a <i>hsf-sbl-m-prt=f</i> 656a <i>sb3lt</i>	
12 th	463a <i>h3p-qsr=s</i>	243a <i>pr-nʿrw-n-nb-st</i>	109a <i>?ʿ3-lm-hh</i>

rum, Leipzig 1883-1891, 28ff. On the general question of the signification of names and of descriptive words or phrases becoming names see H. Khatchadourian, 'The Meaning of proper Names', in *American University of Beirut Festival Book (Festschrift)*, eds. F. Sarrūf and S. Tamim, Beirut 1967, 121-156 especially 125.

Table 4

Hour names from the Sais sun-dial, c. 1000 BC¹⁰

- 1 *wbnt*
- 2 *sšmt*
- 3 *mk nbšš*
- 4 *sš t*
- 5 *nsrnt*
- 6 *'h' t*

Lists of hour designations, which could rather easily be converted into names for the hours, can then be derived from a variety of sources in Ancient Egypt and such lists go back at least to the eighteenth dynasty (c. 1567 -1320 BC).¹¹ Because of the importance of the hours they became, in major temples such as Edfu and Esna, the responsibility of one or more specialised priests (*iny-wrnt*) who determined when rituals should begin and offerings be prepared.¹² As they were an integral part of Egyptian religion it is not astonishing that the hours, named and personified, should have been one of the elements of it that entwined with ideas and beliefs from Græco-Roman religion after the conquest of Egypt by Alexander (332 BC), to produce the syncretic mixture which characterised Hellenistic devotion.

Although the concept of the hour *ῥῥᾱ* as a twelfth part of the day or night had been known in Greece since at least the sixth century BC,¹³ and employed in civil life on sun-dials since at least the fourth century BC,¹⁴ the hours seem not to have been personified until the encounter with Egyptian religion.¹⁵ When this occurred two distinct but related traditions met and to

¹⁰ Ägyptische Museum, Berlin Inv. 19743. It is described in detail by L. Borchardt *Die Geschichte der Zeitmessung und der Uhren Bd I, Lg B Altägyptische Zeitmessung*, in ed. E. von Bassermann-Jordan, Berlin-Leipzig, 1920, 32ff and has often been reproduced. A recent discussion is that by Clagett, *Ancient Egyptian Science*, ii, 95-98 and 463-470, who however is too indulgent to the over-sophisticated interpretation of Borchardt and the wild fantasies of E. M. Bruins, 'The Egyptian Shadow Clock', *Janus* 52, (1965), 127-137. The most recent—and correct—discussion is S. Symons, 'Shadow Clocks and Sloping Sundials of the Egyptian New Kingdom and Late Period: Usage, Development and Structure', *The British Sundial Society Bulletin*, 98.3 (1998), 30-36.

¹¹ Clagett, *Ancient Egyptian Science*, i, 471.

¹² Sauneron, 'Le prêtre astronome'.

¹³ According to J. A. Hild in C. Daremberg and E. Saglio, *Dictionnaire des antiquités classiques*(...), 255 the oldest known usage of *ῥῥᾱ* in this sense is in a fragment of Anacreon speaking of the 'hour of midnight', followed by similar usages in Xenophon (*Anab.* III, 5.18; IV 8.21).

¹⁴ See numerous examples of 12 hour dials in S. L. Gibbs, *Greek and Roman Sundials*, New Haven-London 1976.

¹⁵ 'C'est à Alexandrie seulement que cette acception du mot [i.e. as a personification of a period of the day] fut précisée et qu'elle donna lieu à des allégories'. Hild, *Dictionnaire des antiquités classiques*. Cf. the similar judgement of A. Bouché-Leclercq, *L'astrologie grecque*,

some extent fused: the ancient Egyptian one of personifying and naming the hours, and the younger, but still respectably established, Greek one of personifying and naming the seasons which were also designated as ὥραι. What happened was still clear to the near-contemporary Macrobius (fifth century AD) when he explained that

‘Among the Egyptians Apollo (and he is the Sun) is called Horus—whence the name ‘hours’ [*horae*] has been given to the twenty-four divisions which make up a day and a night and to the four seasons [ἔρᾱ] which together complete the cycle of the year’.¹⁶

By Macrobius’s time there was probably already a considerable choice of names and personalities for the hours. Three centuries earlier, Hyginus, who had a particularly strong interest in names and etymologies and drew on a late Alexandrine source, could refer to different possibilities.¹⁷ The hours were the daughters of Jove and Themis. His first list which contains only nine names, is given in Table 5, his second of eleven names, in Table 6.

Table 5

Hyginus: *Genealogiæ or Fabulæ* : Ch. 183
Probably second century AD

Aux	presumably first light
Eunonia	order
Pherusia	? the act of carrying
Carmo	fruit
Dice	justice
Euporia	abundance
Irene	peace
Orthosie	? the state of being straight
Thallo	flowering

Table 6

Hyginus: *Genealogiæ or Fabulæ*, ch. 183
Probably second century AD

Auge	When the light of the Sun first appears, son of Helios
Anatole	Rising of the Sun or stars, place where they rise, East
Musice	Music (performed in the morning hours)
Gymnastike	Sport (performed in the morning hours)
Nymphe	Hour of the bath

Paris 1899, 478, who suggests further that it was when Greek astrologers replaced the abstract Egyptian hour names by those of the planets that the astrological week was developed.

¹⁶ Saturnalia I.21 13. ‘Apud eosdem (the Egyptians) Apollo, qui est sol, Horus vocatur, ex quo et horæ viginti quattuor quibus dies noxque conficitur nomen acceperant et quattuor tempora quibus annus orbis impletur ὥραι vocantur’. English translation from V. Davies, *Macrobius: the Saturnalia*, New York 1969.

¹⁷ All the following discussion concerning Hyginus is based on H. I. Rose, *Hygini fabulæ*, 2nd edition, Leiden 1963. *The Myths of Hyginus*, ed. and transl. M. Grant, Laurence 1960.

Mesembria	Noon, South
Sponde	Drink-offering before dinner
Telete	Bringing to perfection
Acte	Corn, either standing or ground, and so harvest, the gift of Ceres, surnamed Acte
Hesperis	Of evening, or the West, evening star.
Dysis	Setting of the Sun or stars, place where they set, West

Already in Hyginus the identity of the *horai* as both names and personifications of the season and the hours which would later be noted by Macrobius, is evident. In Table 5 *Carpo* (fruit), *Eunonia* (order), *Dice* (Justice), *Irene* (peace) are the names characterising the four seasons in Hesiod's *Theogony* of some eight centuries earlier.¹⁸ Aux, Carpo and Thallo are the season names that were favoured in Attica,¹⁹ while in Table 6 the association of *Acte* with autumn seems evident. Presumably because the four sisters of the seasons were conceived as attending on the chariot of the Sun as he set out each day on the solar journey, they became absorbed into the 12 *horai* who performed the same task, but with a greater division of labour, when eventually they also became personified. Notable also is how the names of the hours have developed out of descriptions of either the phase of the day or of an activity, associated with it. A similar move from description to name was noted for Egyptian names, and that some of the Greek names such as *Anatole*, dawn, attendant of the East wind gate, and *Dysis*, sunset, attendant of the West wind gate, also have geographical locations is an interesting parallel with the very precisely located Egyptian names for the hours of the night.

Consistency in belief and personification of the kind being discussed here is not to be sought. Rather one should enjoy the variety and exuberance of imagination which is revealed. Where Hyginus absorbs the *Horai* as four seasons into the *horai* as personifications of the hours, Nonnus in the same century explicitly separates them. When the four seasons arrive in the house of their father Helios, he says 'The four were greeted by the twelve circling hours [δωδεκα κυκλάδες ὥραι] daughters of Time, tripping round the fiery throne of the untiring Charioteer in a ring, servants of Helios that attend on his shining car, priestesses of the Lichtgang each in her turn: for they bend a servile neck to the ancient manager of the universe'.²⁰ A century earlier, in Quintus Smyrna, the *horai*, were ambiguous, sometimes escorting

¹⁸ Hesiod, *Theogony* 901-902 but there is some doubt as to the authenticity of this final section of the poem.

¹⁹ G. M. A. Hanfmann in *The Oxford Classical Dictionary*, eds. N. G. L. Hammond and H. Scullard, 2nd ed., Oxford 1979, 527.

²⁰ *Nonnos Dionysiaca*, eds. W. H. D. Rouse, H. J. Rose and L. R. Lind, 3 vols, London, 1940. Bk XII. 15-19.

the day, sometimes the year, and influencing indifferently the hours of the day or of the night.²¹ Still earlier, in the first century between 2 and 8 AD, Ovid related the *horai* exclusively with the seasons.²²

Most of the testimony cited above concerning the *horai* as hour deities is late, but that they had already emerged by the mid-second century AD is clear from the fact that by then they were already being transmitted to India.²³ Probably important, if it could be dated, is the list shown in Table 7 for which unfortunately Claude Saumaise (1588-1653), who preserved it, offered no source,²⁴ and which seems to have very little meaning.

Table 7

Hour names from Saumaise *De annis climactericis*

1	Λαμπή	Lampe
2	Ἀλεξίδι	Alezidi
3	Τερφιθι	Terphithi
4	Φηνου	Fenou
5	Ἐρεβή	Erebe ²⁵
6	Διαγης	Diages
7	Προξα	Proxa
8	Πανφή	Panphe
9	Λοιτία	Loitia
10	Πορφύρα	Porphura
11	Πανφοῦτ	Panphout
12	Τυρφή	Turphe

Lack of meaning, however, was not a disabling characteristic. Knowing the literal or extended meaning of the name of an hour or of its titular deity was not necessary for the priest or devotee who wished to make use of it. Knowing a name gave knowledge of the God or the thing designated by it, and even if the user did not understand the name, the God would. 'He who knows these images' wrote the author of the 'Book of Amaduat' referring to the fourth cavern visited by the Sun-god during his night journey, its name, the name of the gate and of its hour-goddess, 'will eat bread beside the living in the Mansion of Atum'.²⁶ The use of names in Hellenistic religion

²¹ For the day see I.48-51; I. 593-595. Year II. 501-506. Day and night influence II. 595-602.

²² *Metamorphoses* II.1-32.

²³ D. Pingree, 'Decans and Horâs', *Journal of the Warburg and Courtauld Institutes* 26 (1963), 225.

²⁴ Claudius Salmasius, *De annis climactericis et antiqua astrologia diatribæ*, Leiden 1648, 251. Bouché-Leclercq (*L'astrologie grecque*, 479, n. 1) remarked of it 'ce doit être une fabrication de basse époque, ramassée de mots quelconques'.

²⁵ If Erebe is to be connected with Hesiod's Ερεβος 'obscurity', the son of Chaos and father of the day by his sister night, then it implies that Saumaise's list begins counting at midnight, in which case the hours designated must be equal hours as used by astronomers.

²⁶ Clagett, *Ancient Egyptian Science*, i, 495.

was equally supposed to confer understanding and a means of approach to the divine which could eventually lead to favour.

In *The Mysteries of Egypt* (c. 300 AD), Iamblichus explained what the 'names void of signification' implied. 'In reality they are not so meaningless as you think; admitting that they are unknown to us (...) for the Gods (they) all have a sense (...) it is the symbolic, divine and intellectual character of the God's resemblance that one must suppose in the names'. Once the believer knew how to analyse these then, he knew the whole essence of the gods, their power and order. It was, moreover, a duty to address the gods in a language natural to them. In an earlier passage, Iamblichus had even explained the importance of the hours. In the world the Sun is single, immutable and influences everything. But the things thus influenced are multiform and progress around it. The unity and power of the Sun is displayed by the variety that it controls, which is why the Sun changes according to the zodiacal signs and according to the hours 'because these things diversify around the God according to their numerous ways of receiving him'.²⁷

Quite different was the place of the hours in a probably earlier (pre-fourth century) Syriac, gnostic text 'The Testament of Adam'. Here the hours do not by their variety themselves represent the multitudinous facets of the divine being, but they are a part of the knowledge imparted to Adam at the beginning of time and serve as a structure upon which the worship due to God from all created things can be organised. Knowing the names is an integral part of this worship.²⁸

Hour names, then, were an essential part of religion, as they could lead to enhanced understanding and oneness with a god or God. In mystical thought their function perhaps extended no further than this. Once the name of the hour or its tutelary deity or spirit was seen as an attribute both of the hour and of the Gods, it could also be conceived as a way to receive power from the God or spirit and even to obtain influence over him. To achieve this, however, names had to be used correctly and the mystic name tended to lose its coercive power when translated into Greek. In his *Stromati*,²⁹ Clement of Alexandria noted that 'Plato assigns a special discourse (*dialektos*) to the gods and he reaches this conclusion from the experience of dreams and oracles but most of all from those possessed by *daimones*, for they do not speak their own language or discourse but rather the language of

²⁷ I.vii. 3. We have used the edition and translation of E. des Places, *Iamblique: les mystères d'Égypte*, Paris 1964, 191-192.

²⁸ E. Renan, 'Fragments du livre gnostique intitulé Apocalypse d'Adam, ou Pénitence d'Adam ou Testament d'Adam, publiés d'après deux versions syriaques', *Journal Asiatique*, 5e sér. 2 (1853), 427-471.

²⁹ I. 143. 1

the *daimones* who possess them'. Gods and spirits are haughty, unaccommodating interlocutors, sticklers for form and especially for the correctness of their own names. 'The key to success', a modern historian has written, 'was to address these superior beings by their proper names and titles', and he adds that 'in the culture of Late Antiquity it was precisely the use of unintelligible forms of speech that signaled the passage from the lower mundane realms into the sphere of true spiritual conversation with higher orders'.³⁰

The higher religion of yesterday becomes the popular religion of today, and the popular religion of late Hellenism could very easily transform itself into simple magical practice. In such activity the conditions outlined above concerning names took on even greater importance. If spirits, daimons, and angels are to be bound to the magician's will every ritual detail must be scrupulously respected in their invocation. Knowing the names of the hours and/or their governing spirit or deity could help ensure a favourable temporal location for a conjuration. In surviving late Greek magical texts, however, only some spells contain hour indications, so they were not perhaps considered essential by all magicians. To the author of the post-Constantine, probably third century text 'A sacred Book called "Unique" or Eighth Book of Moses', by contrast, they seemed indispensable. The would-be conjuror was instructed (line 30) to present himself 'on whatever auspicious new moon occurs, to the gods of the hours of the day'. The 'great name', it was explained to him, 'is (composed of) 9 names, before which you say (those of) the gods of the hours, with the prayer on the Stele, and (those of) the gods of the days and of those set over the weeks, and the compulsive formula for these; for without these the god will not listen but will refuse to receive you as uninitiated, unless you emphatically say in advance the (names of) the lord of the day and of the hour, which information you will find at the end (...)'.³¹ The names of the lords of the hours, says the author, will be found in the *Key of Moses* together with the appropriate formula for compelling their obedience. Unfortunately, this *Key* seems not to be extant, but it is possible that the names listed there could have resembled those presented in Table 7 or the lists of the names of the

³⁰ *Curse Tablets and Binding Spells from the Ancient World*, ed. J. G. Gager, New York 1992, 9-10.

³¹ Quoted from *The Greek Magical Papyri in translation including the Demotic Spells*, ed. H. D. Betz, Chicago 1986. Cf. some hour indications in F. L. Griffith and H. Thompson, *The Demotic magical Papyrus of London and Leiden*, London 1904, iii.15, p. 35; iv.21, p. 43 and x.21, p. 79 from which it emerges that the time of the year is also significant. In general, however, specific hours are seldom mentioned in this collection and there are no names.

demons controlling each hour of each day of the week found in some later Byzantine magic treatises.³²

The name of the demon controlling an hour and the name of the hour itself, although two elements which could easily become confounded, were nonetheless separate. At least one Byzantine text preserves the actual names of the hours themselves (Table 8), and this text is the more interesting in that for it its author sought validating ancient authority by presenting it as a work of Apollonius of Tyana (first century AD).³³

Table 8

Ps-Apollonius Tyanæus, *De horis diei et noctis*

Day names

1	Ἰαεκ	Iaek
2	Ναουραν	Naouran
3	Ξαρσιαρω	Ksarsiaro
4	Σλαξνε	Slaksne
5	Σαγλατ	Saglat
6	Τη εξμουλ	Te eksmoul
7	Βερουκ	Berouk
8	missing	
9	Ξαπβρουη	Ksaproue
10	Βουξουν	Bouksoun
11	Σημβρου	Sembrou
12	Δακνειουν	Dakneion

Night names

1	Σουξουλουμ	Souksouloum
2	Βεπτερουλ	Bepteroul
3	Ταξραν	Taksran
4	Ἀνξελ	Anksel
5	Κοσγαρ	Kosgar
6	Ζερους	Zerous
7	Μαξλουξ	Makslouks
8	missing	
9	Σοφγου	Sophgou
10	Ξαλτον	Ksalton
11	Γαλγου	Galgou
12	Ἀλσιγκουλ	Alsiggoul

³² R. P. H. Greenfield, *Traditions of Belief in Late Byzantine Demonology*, Amsterdam 1988, 338-346.

³³ The text is edited by F. Boll from Berlin MS 173 (=Phillips 1577), 15th century, in *Commentaria in Aristotelem Graeca vol. 7: Codices Berolinensis*, Brussels 1908, 175-181. Apollonius, a pagan holy man around whom an anti-Christian cult developed in the late 3rd century in Syria was persistently connected with time in later tradition, construction of both a sun-dial and a water-clock at Constantinople being ascribed to him. The sun-dial is described in the *Historia* of Nicetas. For the water-clock see Boll, 175.

The Syriac gnostic text mentioned earlier, which gives descriptions of the activities associated with each hour also exists in an Arabic translation preserved in at least four different manuscripts one of which³⁴ varies considerably from the others. One of its variations is to include a list of the mystic names of the hours which Renan suggests should be compared with those given by Hyginus (Tables 5 and 6) 'of which several are related to the sacred or profane acts which are carried out at each hour of the day or night'.³⁵

Lists of names for divisions of the day or night are not lacking in Arab-Islamic sources, some of them dating from the pre-Islamic period, but the divisions named are not necessarily hour divisions. From the early tenth century onwards however lists of names which are specific to the twenty-four unequal hours are found in several Arabic texts. These lists display some variety between themselves, but stabilising into received, if corrupt, forms in the fifteenth and sixteenth centuries, continued to be copied into the twentieth century.³⁶ A selection of these lists, recently exhumed from the philological sources by David King is given in Tables 9-13. Discussing them King remarks: 'If these lists of twenty-four names had been found only in *late* medieval texts I should not dare to overestimate their importance. But the fact that three, if not four, different lists were known already to scholars in the first half of the tenth century leads me to suspect a still earlier provenance for the idea of naming the hours'.³⁷

Table 9

Hour list of Ibn Raḥiq

<i>Day hours</i>		<i>Night hours</i>	
1	shurūq rise of the Sun	ghasaq	twilight
2	ra'd thunder	fahma	blackness (night)
3	mutū' enjoyment	'ashwa	darkness, gloom or had' quietness
4	tarhil morning	hād'a or hazī'	calm, quiet part of the night
5	hajīr midday heat	surā'	? to travel by night / ? to hurry
6	zawal noon	junḥ or jawz	the middle of night
7	zuhr midday	hazī'	part of the night
8	junūḥ inclination ³⁸	juhma	gloom or 'aq'as
9	ibrād ? cold	buhra	the middle

³⁴ Paris, Bibliothèque Nationale, MS arabe 52

³⁵ Renan, 'Fragments du livre gnostique', 461, n. 2.

³⁶ D. A. King, 'On the Times of the Prayers in Islam', unpublished typescript, pp. 73-74. We are indebted to Professor King for making a copy of the appropriate section of this paper available to us and allowing us to reproduce the lists.

³⁷ Idem, 74-75 (of typescript).

³⁸ Or: diverging or turning

10 ‘aṣr	late afternoon [prayer]	hādī or suhra=sahar	(?) calm, quiet time before daybreak
11 aṣīl	time before sunset	zulfa or sudfa	dusk, twilight
12 ṭafal		bulja	daybreak

Table 10

Hour name list of the philologist Hamza al-Ḥṣṣānī (c. 893-970) in the *Kitāb al-khasā’is wa-l muwāẓana*. There is a similar list in the *Kitāb Fiḥ al-luḡha* by the literary scholar ath-Tha‘ālībī (c. 960-1038) which supplies one name missing from al-Ḥṣṣānī’s list. The same names are also recorded by an-Nuwayrī (see below) although he has muddled up the first few night names.

Day hours		Night hours	
1	shurūq sunrise	shafaq	twilight
2	bakūr early [morning]	ghasaq	twilight
3	ghadw morning	‘atama or ‘atma	first third of the night
4	ḍuḥā forenoon	sudfa	dusk, twilight
5	ḥājira midday	juhma	gloom
6	zahrā noon/midday	zalla	?
7	rawāḥ going, leaving	zulfa	?
8	‘aṣr late afternoon	buhra	the middle
9	aṣīl ³⁹ time before sunset	sahar	time before daybreak
10	‘aṣīl ⁴⁰ evening	fajr	dawn [prayer]
11	ghurūb ⁴¹ setting [of sun]	ṣubḥ	dawn
12	(missing) ⁴²	ṣabāḥ	morning

Table 11

List of Ibn an-Nahhās (d. AD 950) as recorded by an-Nuwayrī (d. AD 1332). The same names are also given by the Egyptian encyclopedist al-Qalqashandī (fl. c. 1400) in the *Ṣubḥ al-‘shā* and by the Egyptian polymath Jalāl ad-dīn as-Suyūṭī (d. AD 1511).

Day hours		
1	bukūr	twinkling of stars
2	shurūq	buzūgh sunrise
3	ishraq	ḍuḥā to shine
4	ra‘d	ghazāla rising Sun
5	ḍuḥā	ḥājira forenoon
6	mutū‘	zawāl noon
7	ḥājira	dulūk to begin to set [of the Sun]
8	aṣīl	‘aṣr late afternoon
9	‘aṣr	aṣīl late afternoon
10	ṭafal	ṣabūb ?
11	‘aṣīl	hadūr going down
12	ghurūb	ghurūb setting [of Sun]

³⁹ Ath-Thā‘libī and an-Nuwayrī give: qasr.

⁴⁰ Ath-Thā‘libī and an-Nuwayrī give: aṣīl.

⁴¹ Ath-Thā‘libī and an-Nuwayrī give: ‘aṣīl.

⁴² Ath-Thā‘libī and an-Nuwayrī give: ghurūb.

Night hours

1	shāhid	witnessing [start of night]
2	ghasaq	twilight
3	'atama	first third of the night darkness
4	fahma	blackness
5	mawhin	?
6	qit'	or qât
7	jawshan	?
8	hutka	disclosure
9	tabāshīr	dawn
10	al-fajr al-awwal	first dawn
11	al-fajr at-thānī	second dawn
12	al-fajr al-mu'tariḍ	the complete dawn [dawn stretching across the sky]

Table 12

Hour names given in a poem by the father of al-'Izz ibn Jamā'a (d. AD 1416)

<i>Day hours</i>		<i>Night hours</i>	
1	shurūq rise of the Sun	shafaq	twilight
2	ra'd thunder	'ashwa	darkness, gloom
3	matā' enjoyment	ghasaq	twilight
4	tarḥāl ⁴³ moving	hād'i'	?calm, quiet
5	hajīr midday heat	surā'	?
6	zühr	junh	darkness
7	zawāl noon	zulfa	?
8	rawāh ?	hazī'	part of the night
9	junūh inclination, diverging	ghalas	darkness before dawn
10	'aṣr late afternoon	saḥar	
11	aṣil time before sunset	fajr	
12	tatfāl ⁴⁴	ṣubḥ	dawn

Table 13

Hour names according to Muhammad ibn 'Abd ar-Rahmān al-Husaynī al-Āmidānī, (no date but 'late').

<i>Day hours</i>		<i>Night hours</i>	
1	shurūq rise [of the Sun]	maghrib or ḥamra	after sunset
2	ra'd thunder	shafaq	
3	mutū' enjoyment	ghasaq	twilight
4	tarḥīl moving	fahma	blackness [of night]
5	hajīra midday	sudfa	dusk, twilight
6	zawāl noon	juhma	gloom
7	zāhīra ?	hudwa (?)	? = hādī', calm
8	junūh inclination, diverging	zulfa	
9	ibrād	buhra	
10	'aṣr late afternoon	suḥūr	
11	aṣil time before sunset	fajr	dawn
12	ṭafal ?	ṣabāḥ	morning

⁴³ tarḥīl

⁴⁴ Or: tatfīl.

That the *idea* of naming the hours is far older than the tenth century should be clear from the lists presented above from Egyptian and Hellenistic sources. That there is any connection between them is not necessarily to be expected. Distinct but similar societies faced with similar problems are not unlikely to arrive at similar solutions, even if these differ in details. Parallels among the names are not difficult to find. Several of them, such as *maghrib* (the place where the Sun sets), for the first night hour and *fajr*, daybreak, for the eleventh night hour in al-Āmidānī's list (Table 13) derive from what the observer sees during the passage from day to night and back again to day, in much the same way as do the names *Auge*, *Hesperis* and *Dysis* in Hyginus's second list (Table 6). Behind the names given to the hours in the Arabic lists as in the earlier ones lie atmospheric phenomena or activities associated with particular hours which serve to identify them. This basis, combined with local mythology, religion, and imagination, served to assure variety and high differentiation in the names given to the hours.

Even so, it may still be worth looking for influences between adjacent societies or between those with strong commercial or cultural contacts. The remark attributed to Jamāl ad-Dīn al-Watwāt (1318) by al-Qalqashandī that Adam first divided daylight into twelve hours and that he instructed his son Seth as to the acts of worship to be performed at each of these hours,⁴⁵ recalls the variant Arabic translation of the gnostic Syriac text, the preamble to which supplies the actual words of Adam to Seth. 'Learn, my Son, the details of the hours of the day and night, the names of these hours, what are the beings that praise God at these hours, how one should pray to God, and at which hour prayer and prostrations should take place'.⁴⁶

Since the translation in which this passage appears is the least faithful to the Syriac original, it may be an addition (even an Arabic one) and is thus evidence of no more than the adaptation of an early text to later modes of thinking. A clearer example of transmission from one culture to another is perhaps provided by hour names in early Latin astrolabe texts which are rough transliterations of Arabic terms

Hototalzacaph sunt linee horarum ipse breues que iacent inter andantiam cancri et capricornii. Supra quas scripte sunt hore a prima usque ad duo X, et sunt XIcim ipse iacentes subtus almucantarāt. In quarum medietate considera insculptum CHATEZEV, uel linea diuidens per medium ipsam tabulam et VIa a prima CHATEZEVVEL, et infra VIIam et VIIIam uides lineam ubi est initium hore HALDOAR, et infra nonam et Xam est CHAT id est linea ubi terminatur HALDOAR id est hora VIa ALGAZAR, quod est hora VIIIIna iniciataur et infra X et XI est extremitas ALGAZAR.

⁴⁵ King, 'On the Times of the Prayers in Islam', 69.

⁴⁶ Renan, 'Fragments du livre gnostique', 463.

(Hototalzacaph are the short lines of the hours which fall between those of Cancer and Capricorn. Above which the hours are drawn from the first to the twelfth, and they are eleven falling below the almucantars. In the middle of which think to engrave Chatezev, or the line dividing this plate by the centre and sixth from the first Chatezevvel, and below the seventh and eighth you see the line where is the beginning of the hour Haldoar, and below the ninth and tenth is Chat, it is the line where Haldoar ends, and below the ninth and tenth is Algazar, which is the beginning of the ninth hour and below 10 and 11 is the last Algazar).

In this text *chat* is a latinization of Arabic *khaff* meaning line, *chatezevvel* of *khaff al-awwal*, meaning first line. This phenomenon of names given in a Latin transliteration, here found in a translation, perhaps by Llobet of Barcelona, of an Arabic treatise on the use of the astrolabe (MS J),⁴⁷ can be paralleled, although the words are not the same, by a more complete list (Table 14) found in the *Liber de astrolabii* which begins *Quicumque astronomiae discere peritiam disciplinae(...)* (MS J) dating from the ninth or tenth century⁴⁸ and explicitly states that it is offering the Arabic names of the hours.⁴⁹ In fact these are not names as such but transcriptions of the Arabic ordinal numbers (first, second, third etc.) which become names in the hands of their Christian users. That on some of the earliest astrolabes to be produced in Latin Europe such names were actually inscribed is suggested by the fact that a virtually identical list was shown on an early illustration of an astrolabe.⁵⁰

Table 14

Hour names from the *Liber de astrolabii*

Hour name	Variants	Origin
1 Elilwihul	Elevil, Eleul	ath-uwla
2 Athenia		ath-thāniya
3 Atheliza	Athelita, Atheliz	ath-thālitha
4 Arrabea	Arabia, Arribea	al-rāb'ā
5 Alchamiza		al-kāmsa
6 Escendeliza	Esscedezza	as-sādisa
7 Escebeha	Ezzebaha	as-sābi'a
8 Ethemina		ath-thāmina
9 Ethezzea		a-tāsi'a
10 Alhamsira		al-'āshira

⁴⁷ J. Millás Vallicrosa, *Assaig d'història de les idees físiques i matemàtiques a la Catalunya medieval*, I, Barcelona 1931, 277.

⁴⁸ *Gerberti postea Silvestri II Papae Opera Mathematica (972-1003)*, ed. N. Bubnov, Berlin 1899, 119.

⁴⁹ 'Et haec sunt illorum nomina Arabica, quae subtus vides formulae inscripta'. (And these are their Arabic names, of which you see the forms inscribed below, MT).

⁵⁰ MS Chartres, Bibl. mun. 214, f. 30 (now destroyed). *Gerberti (...) Opera Mathematica (972-1003)*, ed. N. Bubnov, 119.

11 Aldimatafer	Aldimatafer	al-hādiyyat 'ashrah
12 Etheliaser	Ethelhiafer	ath-thāniyat 'ashrah

The names offered by these two texts are clearly no more than rather uneasy attempts to accommodate in Latin a series of words of which neither the meaning nor the significance was known to their transcriber, whose transcription was also somewhat haphazard. What is more interesting is that the lack of any correspondence between these last two sets of names with those presented in Tables 9-13 seems to imply that the former stem from a quite different literary and perhaps cultural tradition. That the astrolabe linked names derived from Muslim Spain is a not unreasonable conjecture given their date and origin, but it nonetheless requires evidence to substantiate it. Since the names in Table 14 are also without echo in such lists as we have found in later Latin sources they may not have been widely disseminated. Certainly they do not appear on the only known Latin astrolabe which may be ascribed to a pre-twelfth century date,⁵¹ nor on any other known surviving European astrolabe.

Even if it is not yet possible to locate them with any precision, the astrolabe-text hour names deriving from Arabic originals offer a parallel for what also seems to have been the route by which another group—perhaps the most important—of hour names entered European culture. These are the lists of names found in magic-texts from at least the thirteenth century onwards, and in particular in texts concerned with the making of amulets and talismans, and the casting of spells. In the use that was intended to be made of them, the Latin names present clear similarities with those found in the Græco-Egyptian mystical-magical texts discussed earlier and a, somewhat tenuous, link with these is provided by the evocation of Hermes as author or source of inspiration for some of the medieval Latin treatises (e.g. the *Liber lune*). Even though their content is generally a hodge-podge of Græco-Egyptian and Arab-Islamic ideas overlaid with a tincture of Judæo-Christian elements the possibility of some more direct influence from Egyptian sources should not be ruled out, for knowledge of the Sun's night journey in the body of *Nut* has recently been demonstrated from Medieval Ireland.⁵²

⁵¹ See eds. W. M. Stevens, G. Beaujouan and A. J. Turner, 'The oldest Latin Astrolabe', *Physis. Rivista internazionale di storia della scienza*, n.s. xxxii, 1995 of which a 2nd, revised and enlarged, edition is scheduled for publication in late 1998/early 1999.

⁵² J. Carey, 'The Sun's night Journey: a Pharaonic Image in Medieval Ireland', *Journal of the Warburg and Courtauld Institutes*, 57 (1994), 14-34.

Table 15

Michael Scot, *Liber introductorius*, Bk 1, second quarter thirteenth century, Munich, Bayerische Staatsbibliothek MS Clm 10268, f. 108r.⁵³

Lebicum	1	Ariera
Lemorum	2	Debeul
Racon	3	Tabbay
Selachyn	4	Alahyr
Teniatri	5	Tamster
Tenhar	6	Claron
Bador	7	Iafar
Iafacim	8	Cinoatum
Baron	9	Cefaria
Laben	10	Nalhoyñ
Globron	11	Haaloco
Kahiabalon	12	Bendino

Table 16

'Belenus', *de horarum opere*: Inc 'Dixit Belenus qui et Apollo dicitur, Imago primo (...)', British Library MS Royal 12 c. XVIII, ff. 12-13 (fourteenth century).

Night	Day
1 Haÿsesim	Agloy
2 Rebal	Iprose (?)
3 Thaber	
4 Allahair	
5 Camifer	
6 Izaard	
7 Jafar	
8 Cimarū	
9 Cefrar	
10 Malho	
11 Adlatho	
12 Cessarū	

⁵³ We are grateful to Dr Silke Ackermann, The British Museum, London, for communicating this list to us.

Table 17

Necromancer's Handbook, Munich Bayerisches Staatsbibliothek, MS Clm 849 (fifteenth century)⁵⁴

<i>Day names</i>		<i>Night names</i>
Yayn	1	Leron
Yan, Or	2	Latol
Nassura	3	Hami
Sala	4	Atyn
Sadadat	5	Caron
Tamhut	6	Zaia
Caror	7	Nectius
Tariel	8	Tafat
Karon	9	Conassuor
Hyon	10	Algo
Nathalon	11	Caltrua
Abat	12	Salaij

Table 18

British Library, MS Sloane 3826 (works ascribed to Balaminus), late sixteenth or seventeenth century. *Liber lune* (ff. 84r-89v).

<i>Night hours</i>
1 Vebiche
2 Yenor
3 Campher
4 Oelghil
5 Coalel
6 Jenhuno Conchar
7 Jadar
8 Jasolun or Jasumah
9 Bahau or Luxon
10 Sachon or Sahon
11 Jenim
12 Rabalou or Pahiason

Table 19

British Library, MS Sloane 3826 (works ascribed to Balaminus), late sixteenth or seventeenth century. *Liber Salomonis*, ff. 1- 83v (ff. 42v-43r)

<i>Night hours</i>
1 Zedrin
2 hiracl
3 caym
4 hacir
5 Zaron (or Zaran)

⁵⁴ The work has been edited with a full and detailed introduction by R. Kieckhefer as *Forbidden Rites, A Necromancer's Manual of the Fifteenth Century*, Thrupp 1997. The day and hour names are discussed at pp. 182-183 with the Latin text at pp. 306-307.

- 6 Zzya
- 7 Nactilas
- 8 Thasras
- 9 Saphar
- 10 Haloga
- 11 galcara
- 12 Saffa (Saha)

Magic texts were transmitted to Europe, mainly from Arabic, during the twelfth and thirteenth centuries.⁵⁵ The talismans and amulets, of which works such as the *De Imaginibus*, translated by John of Seville from Thābit ibn Qurrah's Arabic original, described the making, were for use. The hour names that were to be uttered at the appropriate time as the mage summoned demons and spirits to give of their power, remained linguistic tools of operative magic until its demise—or at least its disappearance from view—in the mid-eighteenth century. That the names proposed in the different texts only occasionally coincide attests to the variety of different traditions that mingled in these texts and may thus be of help to historians engaged in the tricky task of charting transmission and influences. To be noted, however, is that hour names are only one set of names among many. Names of the angels accompanying each hour, day, week, month and sign of the zodiac, sacred names for God or Christ, for the rulers of the demons, of the demons themselves, of the winds, of the parts of the Earth and many more abound in the magic texts. It may well be, therefore, that future insights into the development of such texts will derive from studying the groupings of name lists between manuscripts rather than from the study of any single set.

Either task however is beyond the confines of the present essay which seeks only to introduce the subject, illustrate the longevity of hour name lists, and to indicate something of their intellectual and cultural context. Crucial in the latter is the uncritical traditionalism of the users of magic texts, their willingness to accept texts as ancient purely because the text thus presented itself by claiming Hermes, Aristotle or Balenos (= Apollonius of Tyana⁵⁶) as their author. A second characteristic is the roots of such texts in religious thought often of a mystical or unorthodox nature. The hour names

⁵⁵ L. Thorndike, 'Traditional Medieval Tracts concerning engraved astrological Images', in: *Mélanges Auguste Pelsner* (...), Louvain 1947, 217-274. D. Pingree, 'The Diffusion of Arabic magical Texts in Western Europe', in: *La Diffusione della Scienza islamica nel medio evo europeo*, Convegno internazionale dell' Accademia Nazionale dei Lincei, Rome 1987, 57-102. C. Burnett, 'Hermann of Carinthia and the *Kitāb al-Istamātīs*: Further Evidence for the transmission of Hermetic Magic', *Journal of the Warburg and Courtauld Institutes*, 44 (1981), 167-169 repr. in C. Burnett, *Magic and Divination in the Middle Ages: Texts and Techniques in the Islamic and Christian Worlds*, Aldershot 1996, ch. vi.

⁵⁶ Plessner in *Encyclopædia of Islam* (2nd edition).

in Michael Scot's *Liber Introductorius* occur in his discussion of the prayers and other activities appropriate to each hour. In the first day hour men pray to God, in the third day hour birds and fishes pray to God and so on. All this is highly reminiscent of the Syriac 'Apocalypse of Adam' mentioned earlier. Scot, however, goes further. It is because demons adore their God during the first hour of the night, which is controllable by the magician, because he knows its name, that this is a good time to invoke and bind spirits. It is because fishes and birds pray at the third day hour that this is a good time to make images to catch them.⁵⁷ The operative magic of the hours is here overlaid onto the older mystical, interpretation which it absorbs and uses for its own purposes. Praying at the proper times was important in both Christianity and Islam.⁵⁸ It was also seen as significant in the interpretation of dreams.⁵⁹ Far later Marsilio Ficino would underline the importance of choosing the right hour by quoting an illustrious thirteenth-century forbear. 'Albert Magnus said in the *Speculum* "for a liberty of judgement that is forced in the choice of the hour is not praiseworthy; it is haste in judgement, not liberty, when you forget about the choice of the hour for beginning great things".'⁶⁰ Albert indeed had gone further. In the eleventh chapter of the *Speculum* he gives a bibliography which specifically includes magic treatises concerning the making of talismans and the proper use of the hour such as the work of 'Belenus' *de horarum opera*. This from its incipit 'Dixit Belenus qui et Apollo dicitur', Thorndike was able to identify with British Library, MS Royal 12 C.xviii from which the hour name list in Table 16 derives.

Comparison of the names in Tables 15 to 19 shows a certain amount of intersection between them. The night names for the hours 3, 4, 7, 9, in Michael Scot's list (Table 15) and those in the 'Dixit Belenus' text (Table 16) are clearly the same, as are those for night hours 6, 7, 10, and 11 of Clm 849 (Table 18) and the *Liber Salomonis* (Table 19). A few names in Michael Scot's list, that is those for the seventh, eighth, and ninth day hours, may connect with their equivalents in the privately owned Sarzana

⁵⁷ L. Thorndike, *Michael Scot*, London 1965, 56.

⁵⁸ D. A. King, *Astronomy in the Service of Islam*, Aldershot 1993 esp. the 3rd section. D. A. King, 'Aspekte angewandter Wissenschaften in Moscheen und Klöstern', *Berichte zur Wissenschaftsgeschichte* 18 (1995), 85-95 and 137-149. *Le Temps chrétien de la fin de l'Antiquité au Moyen Age, IIIe- XIIIe siècles* (Colloques Internationaux du Centre Nationale de la Recherche Scientifique No 604), Paris 1984 esp. the articles by J. Biane and L. Pietri. D. S. Landes, *L'Heure qu'il est. Les horloges, la mesure du temps et la formation du monde moderne*, Paris 1987, 102-107.

⁵⁹ E.g. in the 9th-century Book of Achmet, see L. Thorndike, *A History of Magic and Experimental Science during the first thirteen Centuries of our Era*, New York 1923, i, 292-3

⁶⁰ *The Book of Life*, translation by Charles Boer of the *Liber de Vita*, Irving (Texas) 1980.

magic manuscript although this does not contain names for all the hours.⁶¹ For the identity of some other names a case could also be argued. Some of the names seem to derive from Arabic, others from Hebrew, none of them seem to be influenced by the Arabic astrolabe-text names or the Græco-Roman names of Late Antiquity. Unlike the former however, the magic text names did maintain themselves. Sixteenth- and seventeenth-century copies of manuscripts containing them are known,⁶² while the lists which are included in an eclectic, anonymous sixteenth century printed work which invokes the names of Henry Cornelius Agrippa and Pietro d'Abano⁶³ (Table 20) are virtually identical with those given in Clm 849 (Table 17).

Table 20

Hour names from *Les Œuvres magiques de Henri Corneille Agrippa par Pierre d'Abano, latin et françois, avec des secrets occultes*, Liège 1547, 4-5.

Day names (sunrise to sunset)	Night names (sunset to sunrise)
1 Yayn	Beron
2 Janor	Barol
3 Nasnia	Thanu (Thami)
4 Salla	Athir (Athar)
5 Sadedali	Mat(h)on
6 Thamur	Rana
7 Ourer	Netos
8 Tanic (Thamic)	Tafrac
9 Neron	Sassur
10 Jayon	Aglo
11 Abay (Abai)	Calerna (Calerva)
12 Natalon	Salam

The list resumed in Table 20⁶⁴ is followed in *Les œuvres magiques* by a list of the names of the seasons and farther on in the book by a table giving for each day of the week the names of the angels governing each hour, the hours being indicated by their names, not by a number. Much of this material is reprinted in a seventeenth-century English adaptation by Robert Turner which continued to be reprinted into the eighteenth century.⁶⁵ Turner

⁶¹ For a description of the manuscript see C. Burnett, 'The Conte de Sarzana Magical Manuscript', in: C. Burnett, *Magic and Divination in the Middle Ages. Texts and Techniques in the Islamic and Christian Worlds*, Aldershot 1996, ch. IX. We are particularly grateful to Dr Burnett for providing us with copies of the appropriate pages of the manuscript.

⁶² For example British Library, MS Sloane 3826.

⁶³ *Les Œuvres magiques de Henri Corneille Agrippa par Pierre d'Abano, latin and françois, avec des secrets occultes*, Liège 1547, 4-5.

⁶⁴ It was the communication in 1982 of this list, although not from this source, to Francis Maddison by Peter Drinkwater that provoked the present investigation.

⁶⁵ *Henry Cornelius Agrippa his fourth Book of Occult Philosophy of Geomancy Magical Elements of Peter de Abano Astronomical Geomancy, the nature of Spirits; Arbatel of Magick* (...), transl. Robert Turner, London 1655.

(fl. 1636-1665) is a somewhat mysterious figure⁶⁶ but his other publications show him to have been a fervent iatro-physicist and follower of Paracelsus, and the fact that he is credited with an English version of the spurious Fourth book of Agrippa's *Occult Philosophy* which is entirely devoted to operative magic, even though it does not contain any hour names, also places him firmly in the demonic conjuring tradition.

More learned, and therefore perhaps more respectable, but nonetheless a mage in the same tradition as Agrippa, Johannes Trithemius (1462-1516) was also aware of the power of hour names and of the angels who controlled them. From Table 21 it can be seen that although not precisely the same as any of the earlier lists of names from magic texts, some of Trithemius's names can be paralleled in the earlier lists despite his tendency to Hebraize the forms.

Table 21

Hour and Angel names from Johannes Trithemius, *Steganographia* (...) 1606⁶⁷

<i>Day hours</i>			<i>Night hours</i>	
	Hour name	Angel	Hour name	Angel
1	Samael		Omalhorien	Sabrathan Sabrathan
2	Cevorym	Anael	Panezvr	Tartys
3	Danzvr	Vequaniel	Quabrimon	Serquanich
4	Elechym	Vathmiel	Ramerzy	Iesischa
5	Fealech	Sasquiel	Sanayfar	Abasdorhan
6	Genapherym	Saniel	Thaazoron	Zaazenach
7	Hamaryn	Barquiel	Venaydor	Mendrimon
8	Iasanyrn	Osmodiell	Xymalim	Narcariel
9	Karron	Quabriel	Zeschar	Pamiel
10	Lamarhan	Oriel	Malcho	Jasquarivm
11	Manelaym	Beratiel	Alaacho	Dardariel
12	Naybalon ⁶⁸	Beratiel	Xephan	Sarandiel

The names of the night hours 8, 9, 10, and 11 as given by Trithemius parallel the equivalent numbers in the Belenus text (Table 16). 'Naybalon' or 'Nahalon' for the twelfth day hour recalls the equivalent 'Natalon' in the Ps-Agrippa list in Table 20 and perhaps Nalhoyn for the tenth hour in Michael Scot's list (Table 15) where Haaloco for the eleventh night hour also corresponds exactly with Trithemius's 'Alaaco'. Although attached to the tenth hour 'Haloga' in the *Liber Salomonis* list (Table 19) is perhaps

⁶⁶ The notice of him in the *Dictionary of National Biography* is little more than a bibliography. We are grateful to Anita McConnell for help with questions about Turner.

⁶⁷ Johannes Trithemius, *Steganographia: Hoc est Ars per occultum scritorum animi sui voluntatem absentibus aperiendi certa (...) præfixa est huius operi sua clavis, seu vera introductio (...)*, Frankfurt 1606. Book II of this is entirely devoted to a discussion of the angels who control each hour of the day and the night.

⁶⁸ Or: Nahalon, 123.

also to be associated with 'Hoalco' and 'Alaacho' while 'Zaron' for the fifth night hour in the same list is perhaps linkable with 'thaazaron' for the sixth night hour in Trithemius. The magic text tradition, it seems clear from these examples, was both one and many, the compilers of collections in the overarching tradition eclectically borrowing from the many different strands from which it was constituted.

Multiplicity and ingenuity are indeed two of the fundamental characteristics of hour name lists. Although the Græco-Roman names of Late Antiquity seem to have had little or no presence during the Middle Ages, with the Renaissance revival of the pagan mythology of Antiquity, the *horai* both as personifications of the seasons⁶⁹ and of the hours reappear. Not only do named hours reappear, but they also take on figural form. On a cast, lead sun-dial measuring 55cm x 49cm, once located in the Château de la Reille, commune of Tourtoirac in the Dordogne some 35 kilometres from Périgueux, the hours were represented by roman numerals, by their names and by nude female figures crudely executed in relief who carried the hour numerals on their head (Table 22). In addition the horizontal dial also carried a geographical scale enabling the corresponding times in nineteen different parts of the world to be read off.⁷⁰

Table 22

Sun-dial of the Château de la Reille, ? sixteenth century from de Fayolle, *Mélanges* (...) 1909

5	Lampetie	
6		
7	Phætvse	
8	Egiale	
9	Sterope	
10	Hermetea	
11	Irène	
12		
1		
2	Dice	
3	Rode	
4	Talote	= Thalatie, Telete
5	Carpo	
6	Nomos	= Eunomie
7	Pasiphæ	Daughter of the Sun by Perseis, wife of Minos

⁶⁹ A detailed study of the season *horai* ranging from Archaic Greek times to Early Modern Europe is given G. M. A. Hanfmann, *The Seasons Sarcophagus in Dumbarton Oaks*, 2 vols, Cambridge Ma. 1951

⁷⁰ The Marquis de Fayolle, *Mélanges: ancien église romane de Cadiot, nouveau pot à Chataignes en bronze (...), le cadran solaire du Château de la Reille*, Périgueux 1909.

Although the date of this dial is left unclear by de Fayolle, who seems to suggest, on no very convincing grounds, that it was an eighteenth-century copy of a sixteenth century original, the hour name list is interesting as several of the names correspond with those found in the two lists of Hyginus. Carpo, Dice, and Irene appear in the first shorter list (Table 5), and Talote corresponds perhaps with Telete in Table 6. One name, 'Lampetie' can perhaps be assimilated to the 'Lampe' which begins the otherwise isolated list recorded by Saumaise (Table 7).

While the Château de Reille dial represents all the hours in personified form, a surviving vertical stone sun-dial is itself carried by a figure representative of the hours (Figure 1). Mounted on a column, the figure which surmounts the dial wears the dress characteristic in France and Flanders during the mid-sixteenth century of such allegorical figures, with its exaggerated shoulder-pieces, fluted skirt and what looks like a halo above the head, but which is in fact the floral wreath worn by the *horai* both as personifications of the seasons and the hours.

As its use on sun-dials would suggest, the personification of the hours was a familiar, if not overly common *topos* in Renaissance and Early Modern allegory. In 1664 in the *fête* given at Versailles under the title of *Les Plaisirs de l'Île enchantée*, the twelve hours, paired with the twelve signs of the zodiac were personified as attendants on the Chariot of Time which led forward the four ages, iron, bronze, silver and gold. The latter, symbolised by Apollo, inevitably represented the age of Louis XIV.⁷¹ That only twelve hours are represented implies either that concern was only with the day hours, or that the hours of day and night were thought to be equivalent—an idea which could only occur in an equal hour system, but which links back to Quintus Smyrna's indiscriminant ascription of the *horai* to the day or to the night noted above. A similar assumption that only twelve personifications are needed prevails also in the most recent hour list to be disseminated (Figure 2). This takes the form of a set of printed pictorial message cards given away in packets of the French coffee brand 'Carte noire' for a short time in order to promote sales. Three sets, each of four cards, were included in double packs of the coffee. The figurations of the hours had been specially commissioned but although the artists concerned were vaunted as being 'of talent', the publishers failed to record their names despite stating that each set of four cards 'highly original and unpublished' was signed by a single artist.

⁷¹ J.-J. Gautier, 'L'Imaginaire comme support du luxe: les fêtes royales de Versailles de mai 1664' in: *Luxury Trades and Consumerism in Ancien Régime Paris: Studies in the History of the Skilled Workforce*, eds. R. Fox and A. Turner, Aldershot 1998, 198.

That in the early 1990s the long tradition of the named and personified hours should be used for the banal ends of commercial promotion, is indicative not only of the particular social mutations of the twentieth century, but also of the variety and adaptability of hour-name lists. Playing a role in religion and mystical thought in Ancient Egypt and the Hellenistic cultural region, in the latter the names acquired magical functions which developed strongly in Christian Europe during the Middle Ages. At the same time hour names still played what may have been their original role, a descriptive means of identifying a particular point in the duration of day or night. In Islam this function of the hour names led to some of them being absorbed into religious practice as they came to identify the periods for prayer. Personified and absorbed into Græco-Roman mythology, names also came to serve allegorical and decorative purposes in Renaissance and later European art. Of the origin and evolution of the names, the ways in which they were transmitted or not transmitted, much remains to be discovered. To show that to do so will be worth the effort of historians and philologists, has been the limited aim of the present introductory survey.

APPENDIX

An Armenian list of descriptive hour names of uncertain date, probably early Medieval. Translated by the late Charles Dowsett from B. E. T'umanyan, *Hay astghagitut'yan patmut'yun*, Erevan 1964, 83 (Armenian text; Russian summary, p. 31; English summary, pp. 391-2).⁷²

<i>Day hours</i>	<i>translation</i>	<i>Night hours</i>	<i>translation</i>
1 ayg	daybreak	xawaruhk	darkling
2 cayg	sunrise	aljamulj	dark
3 cayrac'eal	submitted	mt'ac'eal	become obscure
4 caragayt'eal	radiant	salawot	dewy
5 sarawileal	becoming	kamawot (from: kamaw)	voluntarily ?
6 erkrates	world-seeing	bawakan	sufficient
7 sant'akol	fulminating	hawat'ap'eal	chicken fall ⁷³
8 hrakot'	fiery ⁷⁴	gelak	small village
9 hurp'ayleal	shining with fire	lusacem	walking in light
10 t'alant'eal	producing a skin	arawot	morning
11 aralot	glimmering	lusap'ayl	shining with light
12 arp'pot	luminous	p'aylacu	bringing brightness ⁷⁵

According to T'umanyan, the names 'showed the degree of lumination of the Earth's surface'. This list follows lists of the names of the months in the 'old' Armenian calendar, of each day in the month (named after Armenian pagan gods), and of the weekdays; no exact references are given by T'umanyan, but he refers to a 'number of manuscripts preserved in the state library and manuscript repository of Armenia, the "Matenadaran", in Erevan'.

⁷² The transcription follows the system of the *Revue des Etudes arméniennes*.

⁷³ ? = 'time to roost'

⁷⁴ ? from 'hrakat' 'dripping fire'

⁷⁵ Mercur

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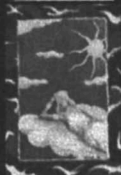


Figure 1 One of the horoi supporting a sun-dial. Stone-carving on a column-shaft, French, sixteenth century: Musée d'histoire des sciences, Genève, nr. 2104. We are most grateful to Mme. M. Archinard for her help and kind permission to reproduce the photograph.

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Figure 2 The horoi represented on a set of coffee cards c. 1990. Private collection.

SECTION TWO

MEDIEVAL ASTRONOMY, COSMOLOGY,
AND NATURAL PHILOSOPHY

CHARLES BURNETT

‘ABD AL-MASĪḤ OF WINCHESTER’*

We owe much of our knowledge of English astronomers in the Middle Ages to John North, whose *Richard of Wallingford, Chaucer's Universe and Horoscopes and History* (among other writings) have provided detailed information on the techniques and personalities involved in the science of the stars on English soil. One scholar, however, has not been mentioned, as far as I know, by North; nor does he appear in the recent comprehensive *Handlist of the Latin Writers of Great Britain and Ireland Before 1540*, compiled by Richard Sharpe (Turnholt, 1997). This is ‘Abd al-Masīḥ of Winchester. The existence of such a scholar can be inferred from the explicits of each of the four completed books of a partial translation of Ptolemy's *Almagest* in the only surviving manuscript of the work: MS Dresden, Landesbibliothek, Db. 87. They read as follows:

1) fol. 15v: explicit primus sermo libri mathemathice Ptolomei, qui nominatur megali xintaxis astronomie translacione dictamine philophonia wittomensis ebdelmessie.

2) fol. 31r: explicit secundus sermo libri mathematice ptolomei qui pre nominatur megalixintaxis sive astronomie translacione dictaminis wintomiensis ebdelmessie.

3) fol. 49v: explicit tercius sermo libri mathematice ptolomei qui pre nominatur melalixintaxis (*sic*) astronomie philophonia translacione dictaminis wittomensis ebdelmessie.

4) fol. 71r: Phylophonia wuttomensis ebdelmessie. Explicit quartus sermo libri mathematice ptholomei qui pre nominatur megalixintaxis sive astronomie translacione dictaminis.

The sense of these explicits is not entirely clear, and has probably been obscured by scribal corruption. They do seem to tell us, however, that (1) such and such a book of the *Mathematica* of Ptolemy has been completed; (2) this *Mathematica* is entitled ‘megali xintaxis’ which means ‘astronomy’; (3) it is in the translation of the dictated copy (?) of ‘wintomiensis (or ‘wit-

* I am grateful for the help of Benjamin Kedar and Fritz Saaby-Pedersen.

to') ebdelmessie' ; (4) this dictated copy (?) is called the 'Philophonia' of the same 'wintomiensis ebdelmessie'.

The only unambiguous element here is the title of the *Almagest*, which is given in the form found commonly in Greek commentators: μεγάλη ξύνταξις, (= 'the great systematic treatise'; 'astronomy' is not a precise translation).¹ The title 'Mathematica', in fact, recalls the original title of the text: μαθηματικὴ σύνταξις or, even more closely, Pappus's usual form of reference to the work as τὰ μαθημαθικῇ. With 'philophonia', we have a pseudo-Greek word, recalling the fashion, especially prevalent in the mid-twelfth century, of calling Latin works by pseudo-Greek titles such as *Dragmaticon*, *Metalogicon*, *Policraticus*, etc.; its intended significance is unclear. The double term 'translatione dictaminis' would suggest that the translation involved two people: one person interpreting the original text orally, perhaps in a vernacular language, and another rendering this intermediate version into good Latin.² This was a common practice among the translators of the twelfth and thirteenth centuries.³ We are left with name of the interpreter: 'wintomiensis ebdelmessie'.

In spite of the variations in transcription, there seems to be little alternative other than to interpret this name as 'wintoniensis ebdelmessie', that is, as 'Abd al-Masīh of Winchester'. Winchester was both a royal and an ecclesiastical centre, and the place where the king's treasure was kept until the 1180s. 'Abd al-Masīh is a common Arabic name, meaning 'servant of the Messiah' (*latine* Servus Christi), commonly, but not exclusively, held by Christian Arabs.⁴ But how can one explain such a combination of an Arabic name and an English toponym?

One clue may be found in the translation of the *Almagest* (henceforth referred to as the 'Dresden *Almagest*') itself. The manuscript was written c.

¹ For references to Ptolemy's work as μεγάλη ξύνταξις/σύνταξις, see P. Kunitzsch, *Der Almagest*, Wiesbaden 1974, 118, n. 17.

² The word 'dictamen' has several meanings, but I take it here as being the noun equivalent to 'dictare', especially since this is the verb used when Abraham ibn Ezra collaborates with an anonymous Latin scholar: see MS British Library, Cotton Vespasian A.II, fol. 40v: 'Ut ait philosophorum sibi contemporaneorum Habraham magister noster egregius quo dictante et hanc dispositionem [*on the astrolabe*] conscripsimus'. The closeness of Ibn Ezra to the scholars involved in the Dresden *Almagest* will be shown below.

³ For examples in translating Arabic works into Latin see M.-T. d'Alverny, 'Les traductions à deux interprètes, d'arabe en langue vernaculaire et de langue vernaculaire en latin,' in ead., *La Transmission des textes philosophiques et scientifiques au Moyen Age*, Aldershot 1994, article III.

⁴ A typical Christian 'Abd al-Masīh is the 'Abd al-Masīh al-Kindī who is purported to have written a letter to the caliph al-Ma'mūn in defense of Christianity: this letter and the corresponding letter of a Muslim constitute the *Apologia* of al-Kindī which was popular both in Arabic and in the Latin translation commissioned by Peter the Venerable, abbot of Cluny in 1138. A Muslim 'Abd al-Masīh was the white Mamluk governor of Mosul, serving Zangī, the sultan of Aleppo in the mid-twelfth century.

1300, and J. L. Heiberg and Charles Haskins, who first discussed the text, hesitated to place the translation much before that date.⁵ Recently it has been discovered that, in spite of appearances and contrary to the judgement of Heiberg and Haskins, the translation was made not from Greek, but from Arabic. Richard Lorch has pointed out that the terminology is based on Arabic forms, and that an addition *vis à vis* Ptolemy's text is also found in a work of the eleventh-century Arabic mathematician, al-Nasawî.⁶ The translator has, however, avoided all Arabic transliterations and added a veneer of Greek or pseudo-Greek terminology. Nevertheless, his use of correct transliterations of Greek names, and the occasional correspondence to the Greek text of the *Almagest*, suggest that he also consulted the Greek version or had the help of someone who knew that version.

The Dresden *Almagest* is not related to any other medieval Latin translation of Ptolemy's work. However, it is not an entirely isolated phenomenon. For, as I have shown in detail elsewhere,⁷ both its distinctive terminology of the translation, and its systematic representation of numerals with the letters of the Latin alphabet (on the analogy of the Greek and Arabic alphanumerical notation) also appear in a work entitled, in the only surviving manuscript, *Liber Mamonis in astronomia a Stephano philosopho translatus*.⁸ This is not a translation, but a cosmology in four books,⁹ in which the author seeks to replace the authority of Macrobius, which epitomizes the learning of his Latin-reading contemporaries, with that of Ptolemy and his successors. In the preface to the fourth book he refers to an unnamed Arab as being his principal guide throughout the work:

Cambrai, Bibliothèque municipale 930, fol. 38r: 'Verum cum in aliis Arabem quendam plurimum secuti sumus, in hoc quoque per multum sequemur, licet quedam de sperarum numero et rotunditatum invenerimus et de circulis quidem et inclinationibus planetarum vera perstrinxit a quibus sperarum numerus dissonat.' ('But since in other [books] we followed for the most part a certain Arab, in this also we will follow [him] through much, although we have found certain things concerning the number of the spheres and their epicycles, and he has touched upon the truths about the circles and the obliquities of the planets with which the number of spheres is dissonant').

⁵ J. L. Heiberg, 'Noch einmal die Mittelalterliche Ptolemaios-Übersetzung', in *Hermes* 46 (1911), 207–216 (esp. 215–216) and C. H. Haskins, *Studies in the History of Mediaeval Science*, Cambridge, Mass. 1927², 109–110.

⁶ Lorch includes an edition of the relevant sections of the Dresden manuscript and al-Nasawî's *Al-ishbā' fī sharh al-shakl al-qāṭṭa'* in his book on the sector-figure [to be published].

⁷ C. Burnett, 'The Transmission of Arabic Astronomy via Antioch and Pisa in the Second Third of the Twelfth Century' in *New Perspectives on Science in Medieval Islam*, ed. J. Hogendijk et al. [to be published].

⁸ This work, too, was first discussed by Haskins, in *Studies*, 98–103.

⁹ The end of the text is missing in the manuscript.

The relationship between the Dresden *Almagest* and the *Liber Mamonis* is so close that one is tempted to propose 'Abd al-Masīḥ as 'Stephen the Philosopher''s unnamed Arab, and Stephen as the unnamed Latin translator of the *Almagest*. But the unnamed Arab could also be the author of the original 'Book of Ma'mūn' (*Liber Mamonis*) whose criticism of Ptolemy corresponds in certain details to that of the *ashab al-mumtahan* (*magistri probationum*) commissioned by the caliph Ma'mūn in the early ninth century to correct Ptolemy's astronomical tables.¹⁰

The sole manuscript of the *Liber Mamonis*—Cambrai, Bibliothèque municipale, 930—was written in the twelfth century. Moreover, it is reasonably certain that 'Stephen the Philosopher' is the same as 'Stephen, the disciple of philosophy' who translated the large medical compendium, the *kitāb al-malakī* (*Regalis dispositio*) of 'Alī ibn al-'Abbās al-Majūsī. We find the same style of literary Latin in both works; we find consultation of Greek as well as Arabic sources; but, above all, we find the same system of alphanumerical notation.¹¹ Moreover, we find a place and a date, or rather, several dates, attached to different books of the translation of the *Regalis dispositio*: the place is Antioch, and the dates all fall within the year 1127. This makes it very likely that Stephen the Philosopher is 'Stephanus thesaurarius Antiochie' for whom a copy of the *Rhetorica ad Herennium* (now MS Milan, Ambrosiana, Cod. E. 7 sup.) was written in 1121. For, this manuscript also uses the alphanumerical notation in the same way as does the *Liber Mamonis*. Richard Hunt pointed out that there was a treasurer called Stephen at the Benedictine monastery of St. Paul, one of the principal religious foundations in Antioch, who had been given a house in the city between 1126 and 1130.¹² This is probably our 'Stephen'. A further biographical detail is given by the twelfth-century medical writer, Matheus Ferrarius, who states that 'Stephen, a certain Pisan, went to those parts [*meaning the Orient* ?], and, learning that language, translated the whole of the *Practica* [*i.e., the practical portion of the Regalis dispositio*]'.¹³

We can conclude from this that, in all probability, 'Abd al-Masīḥ of Winchester interpreted the *Almagest* for his Latin colleague (whether or not this was Stephen) in the second quarter of the twelfth century, and that he

¹⁰ Burnett, 'The Transmission'.

¹¹ The identity of the two Stephens is explored in detail in my 'Antioch as a Link between Arabic and Latin Culture in the Twelfth and Thirteenth Centuries', in *L'Occident et le Proche-Orient au temps des croisades: traductions et contacts scientifiques entre 1000 et 1300*, ed. A. Tihon, I. Draelants, and B. van den Abeele, Louvain-la-Neuve (in press).

¹² R. W. Hunt, 'Stephen of Antioch', in *Medieval and Renaissance Studies* 6 (1950) 172–173.

¹³ 'Stephanon autem quidam Pisanus ad illas partes ivit et linguam illam addiscens eam [*Practica*] ex toto transtulit' (MS Erfurt, Wissenschaftliche Bibliothek, Amplon. O 62, f. 50r).

was working in Antioch, where Arabic, Greek and Latin culture flourished at this period. We might, therefore, seek an explanation of his name in the social context of the Crusader States. Antioch had been conquered in the First Crusade, in 1098, and this conquest was followed by a large influx of Western Europeans ('Franks'). A little before this date (1085), a similar immigration of Franks followed the conquest of Toledo. In this case the settlers started to speak Arabic, and even began to use Arabic names. Thus we find an "Abdallah ibn Chelabert" already in a document of 1095.¹⁴ The possibility that 'Abd al-Masîḥ was the son of a Crusader who came from Winchester, however, is made less likely in view of the fact that in the Crusader States, apparently, the Franks did not become assimilated into the native population in the same way as in Spain.¹⁵ When an Arabic name is associated with a Christian one there, it is more likely that we are dealing with a Muslim who has converted to Christianity and adopted the name of his godfather. Thus a 'Walterus cognomine Mahumeth' witnessed royal charters in Jerusalem from 1104 to 1115, and could have been the same 'Machomus' who was baptized and entered royal service during that period.¹⁶ But 'of Winchester' is not a personal name, and 'Abd al-Masîḥ could have been a Christian in the first place. It is more probable, then, that he was an Arab Christian from the Crusader States who, for some reason or other, was associated with Winchester.

At this point, one may follow up another clue. For the epithet 'of Winchester' is also attached to a set of astronomical tables. The well-read late thirteenth-century philosopher and astronomer Henry Bate, in listing a number of authorities that agree in measuring the movements of the planets in respect to the 'ninth sphere', mentions 'Abraham the Jew, al-Şūfî, and the other *magistri probationum*, and especially Oriental astronomers (...) in the tables of Abraham, of Pisa (?), of Winchester, and others'.¹⁷ It is unclear

¹⁴ See A. Gonzalez Palencia, *Los mozárabes de Toledo en los siglos xii y xiii*, 4 vols, Madrid 1926–30, I, 140, who regards this assimilation as quite common.

¹⁵ See J. Praver, 'Social Classes in the Latin Kingdom of the Franks', in *A History of the Crusades*, ed. K. M. Setton, V, Madison 1985, 117 ff.

¹⁶ See B. Kedar, *Crusade and Mission*, Princeton 1984, 75, who gives several examples of baptised Muslims taking their godfathers' names in the Crusader States and Sicily.

¹⁷ Henry Bate, *Descriptio instrumenti pro equatione planetarum*, which follows his *Magistralis compositio astrolabii* (1274), printed with *Liber Abraham iudei de nativitatibus*, Venice 1485, sig. d4 recto-verso: 'Est enim instrumentum hoc super motus planetarum ad octauam speram relatos ingeniatur et radicum: secundum quod açarkel et alii consideratores quamplures tabulas suas fundauerunt: ut patet in tabulis toletanis: nouariensisibus: herfordiensibus [sic] et aliis pluribus. Ptholomeus vero: et Geber: Albategni: Abrahamque Iudeus: et Açophius ceteri quoque magistri probationum et maxime orientales astronomi motus planetarum secundum nonam speram considerantes radices suas super hoc fundauerunt: et hoc patet in tabulis Ptholomei: Albategni et Abrahe: in tabulis Pisanis vuintoniensisibus et aliis'. The punctuation of the Renaissance printing has been carefully observed.

whether the the two adjectives 'of Pisa' and 'of Winchester' should be separated from each other by a punctuation. The history of the Tables of Pisa is difficult to unravel.¹⁸ This much, however, can be stated with reasonable confidence. They are based on the tables of 'Abd-al-Rahmān ibn 'Umar al-Šūfi (d. 986), which were not known among Arabic astronomers in the West. A Latin version must have been in existence before 1150 when the London Tables were based on them. Abraham ibn Ezra ('Abraham the Jew') wrote introductions to, and instructions on how to use, the Tables, which were written up in Latin in two works, one of 1150 (the *Tractatus Magistri Habrahe de tabulis planetarum*), the other in 1154 (the *Fundamenta tabularum*). Although the terminology of these two works is not the same as the distinctive terminology of the Dresden *Almagest* and the *Liber Mamonis*, in their earliest copies and in the earliest manuscript of the Pisan Tables themselves,¹⁹ the oriental forms of Hindu-Arabic numerals are used.²⁰ Use of these numerals is found elsewhere only in a twelfth-century paper copy of the astrological text, the *Liber trium iudicum*,²¹ and (for the higher numbers)—in the *Liber Mamonis*.²² The *Liber Mamonis* makes frequent mention of a set of astronomical tables for which Stephen the Philosopher

¹⁸ See J.-M. Millás-Vallicrosa, 'El magisterio astronómica de Abraham ibn 'Ezra en la Europa latina', in id., *Estudios sobre historia de la ciencia española*, Barcelona 1949, 289–347 and R. Mercier, 'The Lost Zij of al-Šūfi in the Twelfth Century Tables for London and Pisa', in *Lectures from the Conference on al-Šūfi and Ibn al-Nafis*, Beirut 1991, 38–72.

¹⁹ MS Berlin, SBB-PK, lat. fol. 704, Rose n. 956.

²⁰ The earlier copy of the 1150 text accompanies the Pisan Tables in the Berlin MS, on fols 27r–33v and uses the oriental forms throughout; the later, variant, copy in MS London, British Library, Arundel 377, fols 56v–63, uses the western forms of the Hindu-Arabic numerals (which became our 'Arabic numerals') but includes a key to the oriental forms, which suggests that they were present in a previous copy. Photographs of the numerals in *Fundamenta tabularum* are given in the edition of that text, by J. M. Millás Vallicrosa, *El libro de los fundamentos de las Tablas astronómicas de R. Abraham Ibn Ezra*, Madrid 1947. Millás Vallicrosa, 'El magisterio astronómico', p. 332, considers that the instructions in MS Arundel 377 were written in Winchester in 1164, and (on p. 342) that, on the evidence of the phrase 'si quis fuerit in Anglia (...)' Abraham's treatise on the astrolabe, which accompanies these instructions in the Arundel manuscript, was also written in England. For some criticisms of Millás's hypotheses concerning the astrolabe text and the suggestion that another text, this time on a universal astrolabe, is more likely to be by Ibn Ezra, see J. North, *Richard of Wallingford*, 3 vols, Oxford 1976, III, 162–164.

²¹ MS London, British Library, Arundel 268. The use of paper for a Latin manuscript of this date is highly unusual, and must be due to contact with Arabic manufacturers. Other appearances in Latin manuscripts of the oriental forms of the Hindu-Arabic numerals (which are those which became the norm in Arabic script) are non-current: e.g., as a record of an alternate series to the western forms which is not used, or as 'fossils', mechanically copied by scribes from earlier Arabic or Latin manuscripts.

²² The numbers under 1000 are written in the Latin alphanumerical notation or in roman numerals.

states that he has written the instructions.²³ As already stated, some of Stephen's values correspond to those of the *Magistri probationum* among whom Henry Bate lists Abraham the Jew and al-Ṣūfī.

The 1150 instructions for the Tables of Pisa include the statement that 'these tables were composed according to the longitude of Pisa, which is 33 degrees from the West. But the longitude of Angers is about 24 degrees from the West, and the same is true of Winchester.'²⁴ I have suggested that the mention of Angers (which also occurs in the *Fundamenta tabularum*) and Winchester had something to do with the fact that early in 1150 Henry Plantagenet was invested with the Dukedom of Normandy: his father, Geoffrey, was Count of Anjou (whose capital was Angers), and, by this time, it was becoming clear that he himself would be the next king of England, and Winchester had powerful symbolical importance to English rulers.²⁵ The passage of the Pisan Tables via Angers (and also Bordeaux, whose meridian is mentioned in the *Fundamenta tabularum*) to Winchester and London parallels Ibn Ezra's own itinerary from Tuscany (in the early 1140s) through the South of France to Normandy and eventually (in 1158) to London where he is said to have died in 1161.²⁶

Thus we see, on the one hand, that the Arabic original of the Pisan Tables is unlikely to have come from al-Andalus. Since they share a numerical notation and some values with the *Liber Mamonis* of Stephen the Philosopher (of Pisa and Antioch), it is plausible that they should come to the West by the same conduit as the works associated with Stephen; Henry Bate certainly connects the tables with those of 'Eastern astronomers'. On the other hand, they were used, or at least intended for use, in Winchester.

Whether the bare statement that Winchester has the same longitude as Angers is sufficient to justify calling them the Tables 'of Winchester' is

²³ MS Cambrai, 930, fol. 2r: 'Quoniam in canonem astronomie quas proposueramus regularum exsequ<u>to tractatu promissum exsolvimus, secundum hoc opus (...) aggredior'.

²⁴ MS London, Arundel 377, fol. 56v: 'Hec quidem tabule fuerunt composite secundum longitudinem Pise, cuius longitudo ab oriente est .33. graduum. Andegavensium vero longitudo ab occidente est .24. graduum fere. Eadem est Wintonie.'

²⁵ C. Burnett, *The Introduction of Arabic Learning into England*, London 1997, 46–58. Part of this argument rests on the parallel evidence of Adelard of Bath dedicating his *De opere astrolapsus* to Prince Henry on the same occasion of his investiture, which was set out in detail by John North in 'Some Norman Horoscopes', in *Adelard of Bath: An English Scientist and Arabist of the Early Twelfth Century*, ed. C. Burnett, London 1987, 147–161 (esp. 159).

²⁶ The places of writing mentioned in his Hebrew works are Lucca (some 15 miles from Pisa), Béziers, Evreux, Rouen (the capital of Normandy) and London. These are places with important Jewish communities, for whom Ibn Ezra was providing scientific texts in Hebrew. It is worth noting, however, that Winchester itself, towards the end of the twelfth century, was known as 'the English Jerusalem', presumably because of its significant population of Jews due its position as a financial centre; see *Winchester in the Early Middle Ages*, ed. M. Biddle, Oxford 1976, 539 (H. M. Nixon).

debateable. Moreover, Henry Bate appears to distinguish between the tables of Abraham and those of al-Šūfi. For, in the passage quoted above there is a deliberate pairing of authors and tables, as follows:

al-Zarqāla	Toledan Tables
‘alii consideratores’	Tables of Novara, Hereford, etc.
Ptolemy	
Jābir ibn Aflaḥ	Tables of Ptolemy
al-Battānī	Tables of al-Battānī
Abraham the Jew	Tables of Abraham
al-Šūfi and the other <i>magistri</i>	
<i>probatium</i> and oriental	Tables of Pisa (,) of Winchester,
astronomers	etc.

Whether he, further, intends to distinguish between the Pisan Tables and those of Winchester, is also debateable: the absence of a punctuation between the two toponyms in the Renaissance printing cannot be regarded as decisive evidence. In any event, Henry knew of tables known as the ‘Winchester Tables’.²⁷ As the examples given by Henry himself show, tables tended to be written by astronomers for the meridian of the city in which they were active: al-Zarqāla of Toledo for Toledo, Roger of Hereford for Hereford, Campanus of Novara for Novara, etc. If there were independently-occurring tables of Winchester, they were probably written by an astronomer of Winchester. In the person of ‘Abd al-Masīḥ Wintoniensis we have exactly such a man.

Such a conclusion could be blown over, to use John North’s words,²⁸ by the slightest breath of new evidence. No person called ‘Ebdelmessie’ or the like has been identified in the Winchester Domesday of 1148 or in any other document of the well-researched medieval archives of the city.²⁹ No Arabic-sounding name has been found in these documents, unless one should count ‘Stephen the Saracen’ (Stephanus Sarazinus), who is mentioned in the Domesday and received an annual payment from the Crown of 30s 5d between 1160 and 1184.³⁰ Yet, Winchester was the kind of centre that

²⁷ Since the writing of this article, Fritz Saaby-Pedersen has sent me several further references to ‘Winchester Tables’, including two glosses in MS Cambridge, University Library, Kk.I.1, 145v, mentioning ‘tabule mediorum cursuum solis ad meridiem Winton. ab Abrahamo condite’. These need further investigation.

²⁸ ‘Some Norman Horoscopes’, 160.

²⁹ See the massive volumes of Winchester Surveys, esp. vol. I: *Winchester in the Early Middle Ages* (n. 26 above), and *Chartulary of Winchester Cathedral*, ed. A. W. Goodman, Winchester 1927.

³⁰ *Winchester in the Early Middle Ages*, 134 and 215. ‘Saracen’ is a common surname both in French (Sarazin) and in English (Sarson).

attracted scholars and foreigners.³¹ In the early twelfth century the sessions of the Exchequer were held there, and, as the guardian of the Royal Treasury, it remained the seat of the financial administration of the kingdom until the 1170s. In 1148 royal officials formed one of the wealthiest and most distinctive groups of property holders. The Exchequer and Treasury both required scholars with mathematical competence, and it is no coincidence that the introduction of Arabic mathematics (including astronomy) into England is closely associated with these institutions.³² Moreover, the bishop of Winchester from 1129 until 1171, Henry of Blois, was virtually a second king of England during the power vacuum caused by the civil war, and attracted scholars from far afield to his *curia*. It is quite possible that a scholar from Antioch, such as 'Abd al-Masīḥ, may have temporarily joined the bishop's *familia*, or become a royal official, and consequently acquired the byname 'of Winchester', perhaps even for drawing up astronomical tables for the city. We do, after all, have a nice parallel though going in the opposite direction. The English scholar who may also have been a royal official, Adelard of Bath, whose interests in Arabic mathematics are similar to those of Stephen the Philosopher and 'Abd al-Masīḥ, visited the Principality of Antioch soon after its conquest, and consequently, it appears, acquired the name of the 'Antiochene' ('Antiochenus').³³

³¹ For this and the following assessments of Winchester's significance, see *Winchester in the Early Middle Ages*, passim, and esp., 291, and 472–492.

³² Burnett, *The Introduction of Arabic Learning*, 59.

³³ For the most up-to-date details of Adelard's biography, see Adelard of Bath, *Conversations with His Nephew: On the Same and the Different, Questions on Natural Science, and On Birds*, ed. and transl. C. Burnett with the collaboration of I. Ronca, P. Mantas España and B. van den Abeele, Cambridge 1998.

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BRUCE S. EASTWOOD

CALCIDIUS'S COMMENTARY ON PLATO'S *TIMAEUS* IN
LATIN ASTRONOMY OF THE NINTH TO ELEVENTH CENTURIES

Prior to the twelfth-century recovery of Greek and discovery of Arabic astronomical (and astrological) texts, the character of European astronomy derived from three traditions: computus, classical texts, and observation (including instruments). By the ninth century each of these was involved with the others, producing an increasing variety of ideas and investigations. While the computistical and observational traditions combined in certain ways to bring about more practical and mathematical understanding of solar, lunar, and occasionally stellar motions, generally in the context of reckoning time intervals, the classical tradition led scholars to expand their frameworks for understanding the order and regularity of the heavens created by God.¹ More speculative or theoretical and quite unmathematical in nature, the classical Latin materials that offered astronomical information and doctrines tested the wits of early medieval investigators in quite different ways than did the problems of the other traditions. Among these Roman astronomical works—the writings of Aratus (in translation), Pliny the Elder, Calcidius, Macrobius, and Martianus Capella were predominant—the translation of and commentary upon Plato's *Timaeus* by Calcidius has received the least attention by modern students of early medieval astronomy. Yet the work of Calcidius, especially his commentary, offers us a revealing field for the display of bold exploration, limits of comprehension, and successful innovation in medieval astronomical study more than half a century before the influx of Greco-Arabic works from ca. 1100 onward. Here I present examples of the boldness, the limits, and the successes from three manuscripts of Calcidius from the ninth to early eleventh centuries.

¹ A recent book by S. McCluskey, *Astronomies and Cultures in Early Medieval Europe*, Cambridge 1998, argues that the essence of early medieval astronomy was the problem-oriented and practical traditions of observational and computistical astronomy. While successful in presenting the content of those traditions, it does not properly explain the place of Roman classical astronomical materials in early medieval astronomy. The present study is an example of what McCluskey's book fails to understand.

1. *A ninth-century scholar's astronomical compendium*

The history of Platonism in the Middle Ages has long held an important position in medieval intellectual history with its focus upon Plato's *Timaeus* and medieval studies and uses of that text. An important study by Margaret Gibson pointed to the eleventh century as the beginning of intelligent work upon the *Timaeus*, referring to the earlier, ninth and tenth centuries as a time when it 'seems to have been a venerated curiosity rather than a work that men used and understood. No commentary on the *Timaeus* has survived from this period; nor any good evidence of independent criticism'.² More recently Rosamond McKitterick has shown the limitations of such a view in a thoughtful survey of the *Timaeus* in the scriptoria and libraries of the ninth century, concluding, 'Plato's work seems to have been part of the corpus of works recognized by the early Carolingians as concerning crucial knowledge'.³ For Gibson the commentary by Calcidius was not a topic of concern at all, whereas McKitterick made some references to it and its diagrams. But as a subject of major, even primary, interest among early medieval readers the commentary by Calcidius has aroused no modern attention or study. Yet it was precisely the commentary which was more explicit, more elaborate, and more accessible in its treatment of certain chosen topics from the history of late ancient Platonism. Among these, astronomy is clearly a prime example. Calcidius's commentary provided, often with labeled diagrams, a useful, qualitative introduction to Hellenistic models for stellar and planetary motions along with comment upon their relevance to Plato's doctrines of cosmic and astronomical order.

The availability of Calcidius's translation and commentary in the Carolingian world would seem at first glance to have been spare. Only three manuscripts of Calcidius's translation with his commentary survive from the ninth century, and from the tenth century there are again only three copies of the complete work.⁴ As McKitterick has shown, however, the history of the

² M. Gibson, 'The Study of the *Timaeus* in the Eleventh and Twelfth Centuries', *Pensamiento. Revista de investigación y información filosófica* 25 (1969), 183-194, at 184. She repeated and emphasized this view in 'The Continuity of Learning circa 850-circa 1050', *Vivator* 6 (1975) 1-13, at 12, where she labeled it along with Macrobius 'still exotica in the later ninth century'.

³ R. McKitterick, 'Knowledge of Plato's *Timaeus* in the Ninth Century: the Implications of Valenciennes, Bibliothèque Municipale MS 293', *From Athens to Chartres: Neoplatonism and Medieval Thought. Studies in Honour of Edouard Jeuneau*, ed. H. Westra, Leiden 1992, 85-95, at 95.

⁴ McKitterick, 'Knowledge of Plato', 89-90, gives the three ninth-century mss. From the tenth century there remain the mss. labeled as Ba, Br1, and C1 by J. Waszink in his edition of Plato Latinus, IV: *Timaeus a Calcidio translatus commentarioque instructus*, London 1962/1975, cix-cx; the date of Ba has been revised. In addition to these copies there survives from each of these centuries one copy of Calcidius's translation alone. From the late ninth

late ninth-century Valenciennes manuscript implies a much wider knowledge of Calcidius's work than a simple count of manuscripts suggests. And the activity of excerpting from such a text may tell us even more about the kind of use and understanding it had.⁵

This is exactly the kind of situation we find in an important collection of scientific texts, put together by a scribe who worked at the monastery of Fulda during 827-829, from the second quarter of the ninth century (Paris compend, hereafter).⁶ In the Paris compend a large section surveys the major classical texts with astronomical information. A complete copy of the astronomical book of Martianus Capella, accompanied by extensive glosses, is the leading text, followed by a brief Aratea, then a set of excerpts on planetary astronomy from Calcidius, Macrobius, and Pliny. This set is arranged in three separate chapters. This set of excerpts as a unit deserves separate and thorough study, but here I devote my description only to the selections from Calcidius.⁷ Nine paragraphs from the commentary were interwoven with the materials from Pliny and Macrobius and even brief reiterations from Capella; the reader does not encounter simply a block of excerpts from each author seriatim. The first compiled chapter presented the

century is Vatican Reginensis lat. 1068; see E. Pellegrin, *Les manuscrits classiques latins de la Bibliothèque Vaticane*, II, 1, Paris 1978, 142-143. From the tenth century is Austin (Texas), Ransom Humanities Center Library MS 29 (Phillipps 816), ff. 12v-24r; see Plato, cxii-cxiii, ed. Waszink. Also C. Eder, *Die Schule des Klosters Tegernsee im frühen Mittelalter im Spiegel der Tegernseer Handschriften*, Munich 1972, 78-79, who points out that at least part of this MS was copied in the first half of the eleventh century, although this does not apply to the text of Plato, for at the head of f. 32r, regarding Ellinger of Tegernsee (ca. 975/980-1056), is written, 'Ellinger scripsit istam glosam'. I have seen only a microfilm copy of this codex.

⁵ Selections from six cosmological paragraphs early in Calcidius's commentary appear in a set of excerpts originating in the late ninth century as glosses on Macrobius's Commentary, the earliest witness being Brussels BR MS 10146 (s. IX ex.—X in.), and traveling as a group to many copies of Macrobius. See A. Peden, 'Echternach as a cultural entrepôt in the eleventh century: The case of Macrobius', *Willibrord, Apostel der Niederlande, Gründer der Abtei Echternach*, eds. G. Kiesel and J. Schroeder, Luxembourg 1989, 166-170.

⁶ Paris Bibliothèque Nationale MS lat. 13955, ff. 169. See C. Leonardi, 'I codici di Marziano Capella', *Aevum* 34 (1960), 443-444. Bernhard Bischoff was of the opinion that this MS was written in the second or third quarter of the ninth century. Although it has been given a possible origin of Corbie, W. Stevens, *Cycles of Time and Scientific Learning in Medieval Europe*, Aldershot 1995, Addenda et corrigenda, p.2, for VI, 297 etc., points out similarities between the main scribal hand of Paris 13955 and the hands designated IIa,b,c,d of Oxford Bodleian Library MS Canon. Misc. 353, written at Fulda between 825 and 840. Professor Stevens has been studying the geometrical texts in the Paris codex and informs me in private correspondence that since there is no other evidence of such materials at Fulda, it is quite possible that the scribe was working elsewhere when copying texts into Paris 13955. Alternatively, the texts may have been borrowed for copying at Fulda, but their number and variety suggest that some other sign of their presence at Fulda should have survived.

⁷ I am completing a study of this astronomical collection. Using the standard numbering for the other authors, I note that the excerpts from Pliny's *Natural History* are II, 45-46, 58-61, 63-67, 74-78; the excerpts from Macrobius's commentary on Cicero's *Dream of Scipio* are I.xv.2-17 and I.xix.2-13.

circles on the celestial sphere, drawn from Macrobius and Calcidius. The second chapter, by far the longest, covered the planets ('De ordine planetarum'), using materials from all three authors. The final chapter described the various risings and settings of the planets, based upon selections from Calcidius and Pliny.

Beginning our assessment with some crude quantitative observations, we notice that only material from Calcidius appeared in all three chapters. In the first, brief chapter (less than one and one-half pages) Macrobius was used more extensively than Calcidius. In the closing chapter (just over one page) Pliny was used slightly more than Calcidius. In the central chapter (over five full pages) Calcidius was used more than Pliny and Macrobius together. The composer of this text chose nine sections, or paragraphs, from Calcidius to explain and describe the background of the celestial sphere and the movements and appearances of the planets.⁸

The first of the three chapters, 'De caelestibus circulis', depends upon Macrobius for all the elements of celestial structure and uses the single paragraph from Calcidius (c.69) only to point out the differences and similarities between stellar and planetary motions as they appear against the celestial sphere. In doing this the composer of this chapter eliminated one phrase, deemed unneeded, and inserted two sentences, which could appropriately be called glosses, as they clarified but did not add new matter to the text.⁹

The second chapter, 'De ordine planetarum', opens with the well-known description by Macrobius of the two different sequences for the inner planets, those of the Chaldeans and of the Egyptians; we can call them the planetary orders of Pliny (and Ptolemy) and of Plato (actually Porphyry) for quicker modern recognition. The Chaldean, or Plinian, order placed Mercury and Venus below the sun and above the moon; the Egyptian, or Platonic, order put Mercury and Venus above the sun. The Carolingian composer actually added Pliny's name to those supporting the Chaldean order according to Macrobius. Otherwise no significant addition appears, which does have three omissions from the complete text according to Macrobius.¹⁰ Whereas the excerpt from Macrobius presented two orders, which were the Plinian and the Platonic, and stated a preference for the Platonic order of the

⁸ For convenience I list here all the Calcidian materials used in the compilation. According to the numbering of sections in modern editions, including that of Waszink, *Plato*, the Paris compend uses (in the following order) the sections numbered 69, 74, 85, 77-80, 71, and 70.

⁹ The text of this chapter in Paris 13955 is on f. 56r,8-56v,19, and the Calcidius excerpt appears at f. 56v,8-19. This excerpt, with the exceptions I have noted, corresponds to Calcidius's text in Waszink, *Plato*, 116.1-14.

¹⁰ This chapter is in Paris 13955, ff. 56v,19-59r,24. The excerpt from Macrobius's *Commentary on Scipio's Dream*, l.xix.2-13 is found on f. 56v,19-57r,20.

planets, the composer of the Paris compend chose to complete his chapter on the order of the planets by apprising us of what Pliny and Plato (actually Calcidius) had to say about various planetary motions.

The Plinian section of Chapter Two began by comparing lunar and planetary light and concluded that the planets are much farther from us than the moon. The excerpt then quickly presented the positions of stations for the outer planets and the force of solar rays as the cause of this effect. For the inner planets the stations were different, and much more frequent in Mercury's case. There followed Pliny's description of the separate centers for the various planets, making the earth eccentric to each planet's circle. Finally the Paris compend quoted Pliny for the apogees and the latitudes of the planets.¹¹ These Plinian materials introduced a much more varied picture of planetary motions than had Macrobius. Clearly Macrobius and Pliny offered different images of the celestial order. How should a reader interrelate the two?

Calcidius gave the basis for answering this question. The Paris compend included excerpts which emphasized the apparent character of planetary stations and retrogradations and the relevance of epicyclic motion, then described at length the solar eccentric with an explanation of the varying length of the seasons through the year.¹² Beginning with the reminder that the sun and the moon have neither stations nor retrogradations, the text pointed out that such appearances do occur with the other planets. But these are erroneous impressions, caused by our notion that we are observing motions on the sphere of the fixed stars. The composer reproduced the complete text of Calcidius on this topic and followed it with Calcidius's complete description of an epicyclic account of stations and retrogradations. To ensure the reader's proper understanding of the intention here, the composer inserted one very simple definition of an epicycle, remarkably similar to that which Martianus Capella gave near the end of his astronomy book, and added at the end of the Calcidian section his own summary comment. 'Hac ratione diligenti cura considerata inveniatur secundum physicos quemadmodum et stare atque procedere etiam et regradari stelle putentur cum ille nihil illorum faciant, sed tantum ordinabiliter per circulos suos incedant'.¹³ This remarkable statement seems to put Pliny and Macrobius,

¹¹ Pliny, *Natural History*, II, 45-6, 58-61, 63-7, provide the texts for the composer here. This material appears in Paris 13955, ff. 57r,20-57v,29.

¹² The excerpts and their order of appearance in the compend are: cc. 74, 85, 77-80. They appear in Paris 13955 at ff. 57v,29-59r,24.

¹³ The two sections of Calcidius are those in *Plato*, ed. Waszink 122.3-123.3 and 136.7-137.13. The text of the Capellan insert is, 'Epiclyclus autem dicitur circulus a terra separatus; nec ei imminens id est qui intra se terram non continet', appearing in Paris 13955 at f. 58r,12-13. It seems to have been inspired by the text of *Martianus Capella*, ed. J. Willis, Leipzig 1983, 333.12-13, which reads, '(...) [circulum epicyclum] id est non intra ambitum proprium

who as *physici* have described puzzling or difficult phenomena of planetary appearances, in the role of simple reporters, whose accounts require the explanation according to regular, continuous circular motions of epicycles, which Calcidius has provided here. The epicycles are the correct understanding, and the apparent stations and retrogradations are erroneous impressions.

After marshalling epicycles to account for the major variations in the appearances of the five planets, the Paris compend turned to solar motion and extracted Calcidius's complete explanation of the different lengths of the seasons of the year. Here the device was the eccentric circle. A long, virtually continuous excerpt (cc.77-80) from Calcidius served the purpose, providing not only verbal rationale but also the description of two diagrams to clarify the way in which a constant motion produced the effect of varying motion.¹⁴ In pedagogical fashion the excerpt began by reminding the reader that the apparent inconstancies are not real, for 'there is no inconstancy in divine acts', and only constant circular motion actually occurs.¹⁵ The sun's apparent motion through the zodiac, divided into four unequal lengths of time, each interval within exactly three signs, was then described. The intervals, determined by the equinoxes and solstices, were, beginning with vernal equinox: 94½ days, 92½, 88 1/8, 90 1/8. Not least among the reasons for Carolingian interest in this topic was its significance for computistical studies. A desire to improve understanding of the course and observed speed of the sun must have played a part in choosing this extensive excerpt from Calcidius's commentary, although the composer gives no hint of such a stimulus.

The text proceeded to describe the eccentric location of the earth within the circle of the sun's orbit and the limits of this eccentricity (c.79). Calcidius then interrupted the account in order to mention a dispute among the *mathematici* as to whether the proper explanation here should employ eccentrics or epicycles; some preferred one type of model, some the other. And the inclusion of this point by the composer of the Paris compend is

rotunditatem telluris includere, sed de latere quodammodo circumduci'. The added commentary to Calcidius's description of epicyclic motion appears in Paris 13955 at f. 58r, 23-25.

¹⁴ The text in the Paris compend covers *Plato*, ed. Waszink 124.15-130.16. At only two points did the composer omit sentences as unnecessary; these are at ed. Waszink, 127.11-12 and 127.16-20. In the Paris compend no diagram appears. The diagrams provided in Waszink's edition are taken directly from the examples in Bruxelles Bibliothèque Royale MS lat. 9625-26 and are not always dependable; the diagram for c. 78 (ed. Waszink, 126) is useful, but that for c. 80 (ed. Waszink, 129) is corrupt and does not fit the text properly. The text in the Paris compend appears at ff. 58r, 25-59r, 24.

¹⁵ 'Nulla enim in divinis actibus inconstantia (...).' Paris 13955, f. 58r, 29-v, 1; *Plato*, ed. Waszink 125.5.

important. He was quite willing to abbreviate sections where he found excessive verbiage, but this point was clearly germane to his purpose. For his readers he was emphasizing that uniform circular motions can be arranged in various combinations and that a mathematical astronomer might conceive more than one explanation that preserved uniform circular motion. Calcidius continued with an explanation using eccentrics.

The final section of the long chapter on the order of planetary motions set the eccentric circle of the sun's path within the larger circle of the zodiac, in which the earth was central. This held the earth eccentric to the sun's circle, producing the appearance of a non-uniform motion of the sun as seen against the background of the fixed stars. With the solar circle divided by a vertical diameter and a horizontal line through the eccentric earth into two arcs distinctly greater than ninety degrees and two arcs about ninety degrees or less, the description identified the two longer arcs of the solar circle as the sectors where the sun appeared to travel more slowly. Consequently the two shorter arcs, on the other side of the horizontal line, located the region where the sun passed through half the zodiac in fewer days and appeared to move quicker. The two endpoints of the vertical diameter, designated by Calcidius as five and one-half degrees of Gemini and a similar point in Sagittarius, fixed the points of least and greatest velocity. A middling speed should occur, therefore, at the two endpoints of the horizontal line, which was also the horizontal diameter of the zodiacal circle, in the signs of Pisces and Virgo. The Calcidian design would seem to have made the point very clear—a nice closing argument in support of the larger theme that the celestial bodies move in uniform circular motion and that appearances to the contrary can be adequately explained by geometrical analysis using various arrangements of the circular motions.

The third and last chapter of the Paris compend, entitled 'De vario ortu et occasu planetarum', used two paragraphs from Calcidius, followed by material from Pliny.¹⁶ This chapter offered no theoretical theme or larger structural plan as did the first two chapters in the compend. Instead the excerpts simply brought together details of the varied phenomena of planetary risings and settings. Only by implication, keeping in mind the prior chapters, might a reader assume that even these, more varied appearances of the planets had unperceived regular, constant motions to explain them. That this might be assumed by a mid-ninth-century reader we can say, because Martianus Capella, whose astronomy was known and was part of the Paris

¹⁶ The two paragraphs (cc. 71, 70) used by the composer of the compend are the texts in *Plato*, ed. Waszink 118.14-119.10, followed by 117.20-118.13. From Pliny, *Natural History*, II, 74-8, he drew the concluding sections on planetary risings and settings. The third chapter appears in Paris 13955, ff. 59r,25-60r,5; the Calcidian material at f. 59r,25-v,13.

compend, had described summarily the pattern of slower and faster risings and settings for constellations of the zodiac.¹⁷ Given this order in the varied risings and settings of constellations, one could expect that an analogous order should emerge upon adequate investigation into the risings and settings of the planets. However, it would suffice for the reader to learn the distinct and different risings and settings for each planet.

These three chapters in the Paris compend allow us a remarkable insight into Carolingian study of planetary motions at or before mid-century. The choice of authors, the choice of topics for selection, and the intelligent abbreviation, changes in sequence, and occasional insertion of the composer's comments—all these indicate a relative sophistication in comprehension of the subject. Especially noteworthy is the clear and explicit Carolingian recognition of Hellenistic models for planetary motion. The clear, still qualitative, awareness of the basic patterns of eccentric and epicyclic models as well as their interchangeability is intriguing. While we need to know more before trying to explain what place this sort of knowledge had in Carolingian schools or independent studies, we can remind ourselves of the few things we do know about it. In the manuscript it is clearly part of a larger collection of astronomical works. These in turn are combined in the manuscript with other quadrivial texts, including some Euclidean geometry.

The manuscript would seem to be more than a compilation of materials by a scholar with interests in these topics, for we have seen in the three chapters on planetary order and motions certain additions that are intended to clarify points at a fairly simple level; this implies the instruction of a reader. Some speculation seems to be in order here. The emphasis in the discussion of planetary models is upon fundamental regularity behind superficial irregularity. This may well have been intended to emphasize for others not only astronomical theory but also the cosmological and even theological lesson that God has ordered the world, especially the heavens, in ways we have not previously understood but may begin to learn better through the study of the arts.

2. *Abbo of Fleury and Calcidius*

By the late tenth century, despite the small number of surviving manuscripts of Calcidius, the biography of Euraclus, a former teaching master at Bonn and subsequently bishop of Liège (951-971), witnessed a familiarity with Calcidius's commentary and specifically with the astronomy it contained.

¹⁷ *Martianus Capella*, ed. Willis, 319.3-320.6 (Book VIII, sects. 844-5).

Euraclus, said his biographer, had gained detailed knowledge of the movements of sun and moon from the works of 'Pliny, Macrobius, Calcidivus, and many other authors'.¹⁸ In a codex of the beginning of the eleventh century (after 1004), Berlin Staatsbibliothek MS Phillippus 1833 (Rose 138), there exist two full pages (folio 37 recto and verso) of abbreviated and modified texts from Calcidivus, all concerned with astronomy and cosmology. In the first part of the codex is the commentary of Abbo of Fleury on the *Calculus* of Victorius of Aquitaine; the second part, which has the folio of Calcidian text as an inserted leaf, comprises 'the most logically ordered copy' of Abbo's computus.¹⁹ Already in the ninth century the abbey of Fleury had been a member of a group of Loire centers that collaborated and exchanged exemplars and even scribes. From these scriptoria had come the greatest concentration of classical texts during the reign of Charles the Bald. In the time of Abbo (ca. 940-1004) the school and the scriptorium of Fleury were active and famous, and relationships with other Loire valley writing centers were at least as close as they had been in the mid-ninth century. In the midst of all this industry and interchange, the wide use of authors like Macrobius and Calcidivus is not surprising.²⁰

Folio 37 in the Berlin manuscript (see Appendix below) provides an intelligent adaptation of Calcidivus. It obviously functions as a set of clarifying statements for a group of astronomical diagrams appearing on the pages immediately before and after the folio. Almost all of these diagrams were excerpted from a complete copy of Calcidivus, almost certainly at the direction of Abbo of Fleury. Yet the folio we are concerned with in Abbo's computus was added after the composition of this copy, leaving us uncertain

¹⁸ B. Pez, *Thesaurus anecdotorum novissimus*, Vienna 1721, IV, iii, 155-166, at 162.

¹⁹ The Berlin MS of Abbo's works is described in detail by V. Rose, *Verzeichniss der lateinischen Handschriften der königlichen Bibliothek zu Berlin*, Berlin 1893, I, 308-315, the folio of Calcidian texts at 312. This manuscript, ending with Abbo's letter of 1004 to Geraldus, seems to have been produced soon after Abbo's death in 1004. Regarding the Fleury context see the brief entries in M. Mostert, *The library of Fleury. A provisional list of manuscripts*, Hilversum 1989, 47 (BF012-4, esp. BF013). Abbo's computus in Phillippus 1833 was briefly described by A. van de Vyver, 'Les oeuvres inédites d'Abbon de Fleury', *Revue Bénédictine* 47 (1935), 125-169, at 150-154. For an excellent introduction to Abbo's philosophical tendencies as seen in his commentary on Victorius's work, see G. Evans and A. Peden, 'Natural Science and the Liberal Arts in Abbo of Fleury's Commentary on the Calculus of Victorius of Aquitaine', *Viator* 16 (1985), 109-127. For an introduction to Abbo's philosophical tendencies in his computus, see E. Engelen, *Zeit, Zahl und Bild. Studien zur Verbindung von Philosophie und Wissenschaft bei Abbo von Fleury*, Berlin 1993, chs. 1-6, 10. (I do not recommend the intermediate chapters in this book.)

²⁰ On the interactions of the Loire valley centers see R. McKitterick, 'Carolingian Book Production: Some Problems', *The Library*, 12 (1990), 1-33, at 8-10; Mostert, *Library of Fleury*, 21-24. On Macrobius at Fleury, B. Barker-Benfield, 'A Ninth-century Manuscript from Fleury: Cato de senectute cum Macrobio', *Medieval Learning and Literature. Essays presented to Richard William Hunt*, eds. J. Alexander and M. Gibson, Oxford 1976, 145-165.

about the identity of the composer of the folio. Since the main text of Phillipps 1833 appears to have been copied after 1004, folio 37 was inserted (and presumably composed) after 1004. The computus appears on folia 23 recto to 53 recto of the codex, and within the composition the only pages not devoted solely to computus are 36 recto to 39 verso. Here there appears, in addition to the inserted Calcidian texts, a long series of images, almost all of which originally illustrated texts of Macrobius, Pliny, and Calcidius, primarily astronomical or cosmological in nature.²¹

As in other computistical collections of the Carolingian and post-Carolingian era, the inclusion of astronomical and cosmological materials was frequent. The use of Plinian diagrams was established with the organization of the materials for the Computus of 809, and Abbo used information from Macrobius and Calcidius earlier in the same manuscript, in the commentary on Victorius's *Calculus*.²² What is remarkable for a computistical collection, however, is the extent of the material from Calcidius. The thirteen Calcidian figures were chosen and included by Abbo, although we are uncertain about the Calcidian texts. Abbo's interest in astronomy as such, in addition to computus with its limited and traditional group of diagrams and shorter excerpts from Pliny, Macrobius, and Martianus Capella, appears in this novel addition of astronomical diagrams from Calcidius.²³ And despite the obvious status of the Calcidian texts as an

²¹ More precisely, the two circular images on the left side of f. 36r are from Macrobius, though the planetary information written within the upper rota comes from Pliny and Calcidius. The three images on f. 39v are all Macrobian. The images on ff. 38v-39r are essentially computistical, though two are cosmological and the eclipse diagram (f. 39r) would fit equally well in an astronomical or in a computistical text. The nine images on f. 36v are all from Calcidius. On f. 38r the three rotae at the top as well as the small image immediately below, labeled 'De heliacis giris', are taken from Calcidius. The small diagram to show nighttime, located in the second range of figures, appears to be generic; I do not know an origin for it. The two large rotae in the lower half of f. 38r are Plinian diagrams, the left to illustrate apsides, the right a circular latitude diagram. Below these are, on the left, a modified Plinian rectangular diagram for latitudes, and on the right a chart with the principal signs of the planets at the Creation, according to Macrobius, *Commentary on Scipio's Dream*, I.xxi.24. In sum, of the eighteen images facing the inserted leaf, f. 37, all but five are from Calcidius's commentary on the *Timaeus*.

²² For the development of Plinian diagrams in Carolingian and later computus, see B. Eastwood, 'Plinian astronomical diagrams in the early Middle Ages', *Mathematics and its applications to science and natural philosophy in the Middle Ages*, eds. E. Grant and J. Murdoch, Cambridge 1987, 141-172. For Abbo's use of Macrobius and Calcidius in his commentary (Phillipps 1833, ff. 7v-22), see Evans and Peden, 'Natural Science', 113 nn. 24 and 27, 114 n. 28, passim.

²³ The Calcidian material clearly gained the attention of later scholars and publishers of computistical texts, for, under the heading of 'vetus commentarius', these Calcidian diagrams were published in conjunction with Bede's *De natura rerum* by Noviomagus in 1537, and they appear with the Plinian diagrams in the 'glossa et scholia' to Bede's work in the more accessible edition of J. Migne, *Patrologia latina*, Paris 1862, v. 90, coll. 219-30.

insertion into the computus, the content is defensible as Abbonian, and the script fits the Fleury scriptorium of the time.

The sixteen sections of Calcidius's commentary represented in this set of clarifying descriptions are in part extended excerpts, in part abbreviations, and in part significant revisions of the original text. Where the original described labeled diagrams that appeared in reserved spaces within the text, the version in Abbo's computus preserved the complete description, but commonly omitted Calcidian phrasings that added no clarity. This sort of abbreviation appears throughout the excerpts. In one case the amount of material from a paragraph (c.110) was so limited that the resulting single sentence was itself drawn from two sections (cc.110-11). A number of paragraphs were revised for greater simplicity, but the composer changed one description in ways that created a new diagram and seem to have constituted a correction to a corrupt figure in the exemplar of Calcidius (c.111).

Looking at these texts and their arrangement more carefully, the reader can raise some useful questions. Noticing that the texts follow exactly the sequence of the diagrams, with one reasonable exception, the absence of an explanation for the first diagram and the truncated reference to the last, non-Calcidian diagrams arouses some curiosity. For each of the eighteen diagrams (1.1-1.9, 2.1-2.9) on folia 36 verso (Figure 1) and 38 recto (Figure 2), proceeding from left to right and by row from top to bottom, we can give a label to the diagram and indicate for the first thirteen the corresponding Calcidian text, found in the appendix below.

- 1.1. Divisiones anni. Calcidius c.79 in space around diagram.
- 1.2. Eccentric solar motion. Calcidius c.80.
- 1.3. Epicyclic solar motion. Calcidius cc.81-2.
- 1.4. Planetary epicycle. Calcidius cc.85-6.
- 1.5. Solar eclipse. Calcidius c.88.
- 1.6. Lunar eclipse, cylindrical figure. Calcidius c.89.
- 1.7. Eclipse, figura calathi. Calcidius c.90.
- 1.8. Essentiae sectio. Calcidius c.92.
- 1.9. Una essentia, duo circuli. Calcidius c.92.
- 2.1. Earth's shadow, conoides. Calcidius cc.90-1.
- 2.2. Elongation of Venus from Sun. Calcidius cc.110-11.
- 2.3. Epicyclic model for elongation of Venus. Calcidius c.112.
- 2.4. De heliacis giris spera. Calcidius c.116.
- 2.5. Unde sit nox (two sides of earth). No text.
- 2.6. Planetary apsides (Plinian diagram). No text.
- 2.7. Planetary latitudes, circular form (Plinian diagram). No text.
- 2.8. Planetary latitudes, rectangular form (Plinian diagram). No text.
- 2.9. Signs of planets at Creation. No text.

Of the eighteen images (nine in each of Figures 1 and 2), only the Calcidian images have accompanying texts on folio 37, except for the first image. This diagram has its adapted text from Calcidius copied within the containing square that is drawn around the picture; only the final part of the numbered section (c.79) appears at the beginning of folio 37 and not within the square containing the image. The order of the images differs from the sequence of texts at one point because of the needs in spacing the diagrams. Diagram 2.1 (cc. 90-1) was separated from the prior eclipse diagrams (1.5-7), since it was too large to fit into the space now held by diagrams 1.8-9 (c. 92), and so their positions were exchanged.

The final sentence of the reverse side of folio 37 offers a clue to the assembling of the diagrams. Referring to the two Plinian rotae, diagrams 2.6-7, the sentence begins, 'Supersunt due rote (...).' Since the two rotae are, in fact, after this statement and not above it, the sentence appears to have been copied from an exemplar which held the rotae followed by the sentence. Combining this clue with the fact that all of the necessary text (from c.79) for diagram 1.1 was copied into the diagram space, we can hypothesize the following. Exemplars for all the diagrams in Figures 1-2 existed in the form of images in direct contact with their respective texts, now found on folio 37. The initial intention of the director of copying the diagrams and texts was to retain this arrangement as seen in diagram 1.1. The intention carried over to diagram 1.2, which appears within a square just like that for 1.1; the square would serve to enclose and identify the text for the diagram. But a quick look at the text from c.80 shows that it could not fit into the space around diagram 1.2. No further diagram is encased in such a square. After the copying of the text into the square for diagram 1.1 and before beginning the text for 1.2, a decision was made to copy continuously on a separate sheet all further texts for these diagrams on folia 36 verso and 38 recto. This decision also allowed a few additions from the original text of Calcidius which gave more than descriptions of the images. The closing section of c.79, which begins the texts copied on folio 37, fits this situation precisely. It does not in any way add to the description of the diagram, and its addition tells us that a copy of Calcidius's commentary was at hand for consultation when the sentence was added. Other material on folio 37 fits the same category as this added sentence from c.79. The final sentence, referring to the Plinian rotae, suggests that no further text accompanied those diagrams. Diagrams 2.5-8 carry labels that may have been sufficient for their comprehension, as they were images which were often found in computistical compilations of the time. Diagram 2.9 was an Abbonian composition whose full meaning

remains unclear.²⁴ The Calcidian images by contrast were not usual—they may have been completely novel—in computus. Even the Calcidian eclipse diagrams, presenting a topic common in computus, were unfamiliar, because they presented a variety of situations and so required written explanation to ensure understanding of the precise differences among them.

The convenient fit of the Calcidian texts on the two sides of the inserted leaf—not even a short space at the end of the composition—suggests that the decision to copy separately required a good bit of planning in order to fit the texts into the two sides of the added sheet. Once again, the presence of a complete copy of Calcidius would have made this task much more feasible, presenting all the texts to be copied in spaced lines on pages. The obvious alternative to such an interpretation of the composition of the two pages of diagrams and the two pages of texts is that the diagrams and texts already existed as exemplars in the form we now see them, but this only pushes back a step the same question. Why do the texts and diagrams appear in the forms we have before us in Abbo's computus? The answer proposed is the only one offered here.

None of the diagrams is unusual; each of the precise forms found in the first thirteen images appears in the extant manuscripts of Calcidius's work from the ninth through the eleventh century. The choice of topics from Calcidius, both the diagrams and the accompanying texts, is somewhat familiar. In the Paris compend there was a strong interest in planetary anomalies, also. Here in Abbo's computus the unusual choice, for a computus, of such elements means an increased interest in reasoned, or geometrical, explanation of certain entities such as the differing lengths of the seasons and the retrograde motions of the planets. And to these topics was added the notable question of the reason for the limited elongations of the two inner planets, Mercury and Venus, from the sun. Like the Carolingian Paris compend, which was not part of a computus nor in any way derived from one, the Abbonian work attends carefully to the relationship between epicycle and eccentric and the possibility of their exchange in an explanation. The abbreviations and modifications of Calcidius's text at various points often increase the clarity of the descriptions. In one case, explained below, a notable change in the text for these diagrams calls our attention to an unexpected and significant connection.

²⁴ The chart in Diagram 2.9, as indicated by the label at its bottom, contained a set of planetary intervals (regulares) to lead to a date. A clearer example appears in Vat. MS Regin. 1573, f. 52r (s. XI), and fuller context appears in R. Thomson, 'Two Astronomical Tractates of Abbo of Fleury', *The Light of Nature*, eds. J. North and J. Roche, Dordrecht 1985, 132-133. The assumption of McCluskey, *Astronomies and Cultures*, 152-153, that these regulares are years for single planetary revolutions seems clearly erroneous.

A change in text occurs in the initial description of the bounded elongation of Venus (cc.110-11). Referring to the diagram 2.2 on folio 38 recto, we recognize, on reading the text of Calcidius for this diagram, that its form in this copy of Abbo's computus is extremely corrupt. Nor is this Abbo's or his copyist's fault. Every extant example from the ninth or tenth century is corrupt, and the design appearing here in Phillipps 1833 is very much in accord with the corrupt designs found in the surviving copies from Abbo's time or earlier. Did the eleventh-century composer of the Calcidian text for diagram 2.2 understand this? If so, why did he not change the design? It appears that he probably did understand that the diagram was erroneous, but he did not correct it. The diagram had already been adopted and copied into the page of the computus before the additional sheet of explanatory texts was inserted. Hence the possibility emerges that the explanatory text on folio 37 verso for diagram 2.2 was composed with a different image in view, a corrected image for the bounded elongation of Venus.

The modest change in the text is the addition of the directional terms, indicating right and left. These terms were not part of Calcidius's text. Furthermore the terms are used in a way to make it impossible to apply the verbal explanation in folio 37 verso to the visual image of diagram 2.2. Very simply, after referring to the fifty-degree arc to either side of the sun's observed position at B, an arc that marks the limit of Venus's departure from the sun, the Abbonian author identifies the line XA from the earth to the observed position of the planet as the straight line on the right side, and the straight line XG as the limiting line on the left side. Looking at diagram 2.2, we can see two things immediately. First, there is no X in the diagram. Second, the point A is to the left side of the diagram, and the point G is to the right. We might suppose the copyist had erred, had he not included the use of point X, which should in fact be in the diagram but is not in diagram 2.2. If we then read through the text of c.111 in the form given by the composer, we find it to be consistent. When composing the text, he was not looking at diagram 2.2.

A search to find a likely image used by our composer of the Calcidian text in Abbo's computus produces almost no positive results. Of all surviving manuscripts of Calcidius's commentary from the ninth to eleventh centuries we can point to only one that has the location of the observer marked by X and, more importantly, the point A to the right and the point G to the left in the diagram. This manuscript, Wien Nationalbibliothek cod. 443, of the first half of the eleventh century, contains a figure for the observed maximum elongation of Venus (cc.110-11) that is unlike any from contemporary or earlier surviving manuscripts (Figure 3). It is clearly a

reconstruction of the proper diagram on the basis of the text rather than a copy of an exemplar.²⁵ The similarity of the text in Abbo's computus with the diagram in a distinct and geographically removed manuscript of Calcidius's commentary rather than with the diagram on the facing page of the computus gives a modern investigator quite a surprise. Relatively little is known about this manuscript. The text of the *Timaeus* and Calcidius's commentary in the Vienna manuscript dates somewhere from ca. 1000 into the first half of the eleventh century. Written in many hands, it was composed at the priory of the Augustinian canons of Maria Magdalena at Frankenthal in der Pfalz and remained in the possession of the priory in the thirteenth and fifteenth centuries.²⁶ None of this suggests a connection with Fleury sometime during the previous half century, thus allowing only speculation or silence. The sole observation to make at present is that the eleventh century was the period of greatest copying and spread of Calcidius's commentary, with and without the *Timaeus*.²⁷ It is therefore perhaps easier to imagine at this time a transfer of some intermediary between the Phillipps 1833 version of Abbo's computus and the Vienna copy of Calcidius. It is unclear which of these two manuscripts was earlier, and the nature of their intermediary is also unclear.

The Calcidian texts on folio 37 of the Berlin Phillipps manuscript, in combination with the astronomical and cosmological images on the two facing pages, offer us many insights into the knowledge and use of Calcidius's commentary for astronomy near the end of the tenth century. Fleury had an active school and an active scriptorium at the time. Abbo obviously took maximum advantage of the materials available there in composing his computus, and he could certainly request further works from more distant sources. By his time Fleury must have had its own copy of Calcidius, and the images in Abbo's computus are likely to have derived from that copy. But another Calcidian source as well was available to the composer of the texts on folio 37 in the computus. This scholar knew his Calcidius. His abbreviations of Calcidius's somewhat prolix wordings show a sure hand. While the planetary diagrams we have been considering were in combination with more traditional computistical materials, these planetary models and their texts attended explicitly to qualitative geometry and

²⁵ The image appears at f. 183r, following the text it describes. An extended study of the text and diagram for cc.110-111 in a different context was made by B. Eastwood, 'Heraclides and Heliocentrism: Texts, Diagrams, and Interpretations', *Journal for the History of Astronomy* 23 (1992) 233-260, esp. 244-251 and Fig. 6 (same as Wien 443, f. 183r).

²⁶ O. Mazal et al., *Wissenschaft im Mittelalter. Ausstellung der österreichischen Nationalbibliothek, Prunksaal* 1975, Graz 1980, 185 (Nr. 156).

²⁷ Gibson, 'Study of the *Timaeus*', 184, 190. At least 18 mss. of Calcidius's commentary survive from the eleventh century; see Waszink, *Plato*, cvii-cxxxi.

theoretical explanations. Abbo and others associated with his computus had in mind more than the quantities of solar and lunar motions needed for calendrical and chronological purposes. In Abbo's computus, with the inclusion of Calcidian diagrams and texts for models of planetary motions, we have found a new step in the early medieval rationalizing of time and the order of Creation.

3. *Eleventh-century improvement of Calcidius*

The study of the *Timaeus* and the study of Calcidius's commentary on Plato's work were distinct enterprises. In many ways Calcidius's commentary can be called a late ancient and Platonistic encyclopedia but not a well integrated philosophical statement. Of course, a commentary is not usually meant to be the latter sort of writing. Calcidius's commentary served as a mine of information, potentially quite distinct from, though not contrary to, Plato's work. Certainly Abbo of Fleury used Calcidius in this way, choosing discrete doctrines and useful diagrams but not committing himself for or against something called Platonism. The distribution of surviving manuscripts of Calcidius's commentary and of the *Timaeus* without the commentary show a chronological shift from the commentary to Plato's work itself. Prior to the eleventh century, three extant copies of Calcidius's translation and four surviving copies of his commentary were made. From the eleventh century, we have four copies of the *Timaeus* alone, two copies of the commentary alone, and seventeen copies of the *Timaeus* together with the commentary by Calcidius. From the twelfth century, there survive thirty-nine copies of the *Timaeus* without the commentary, four copies of the conjoined *Timaeus* and commentary, and four copies of Calcidius's commentary unaccompanied by Plato's work.²⁸ A rough but not inappropriate conclusion would be that the eleventh century saw the study of astronomy and cosmology as much, if not more, through Calcidius as through Plato, whereas the twelfth century saw a decline in interest in much of Calcidius's information and explanations along with a sharp rise in

²⁸ In referring to the *Timaeus* I always mean Calcidius's translation, not the incomplete and little-copied translation by Cicero. Also, my count of texts by century of the *Timaeus* and of the commentary is a count of the part that presents the macro-cosmology and the astronomy. Waszink's edition preserves the medieval divisions as follows. *Timaeus* (1) = 17A-39E in the traditional numbering of Plato's dialogue; *Timaeus* (2) = 39E-53C. The commentary of Calcidius was similarly divided to accompany this partition of the dialogue. Commentary (1) = cc. 1-118; Commentary (2) = cc. 119-355. My count of the manuscripts, drawn from Waszink's list and from other catalogues, is solely for *Timaeus* (1) and Commentary (1), separately or in combination.

interest in Plato's cosmology apart from the late ancient doctrines of Calcidius.

Along with Martianus Capella, Calcidius was the Roman source that gave the most rationalized account of planetary motions for scholars in Western Europe during the eleventh century. While computistical studies were being reformed and the astrolabe began to be used for more precise data in the service of time-reckoning, parts of the celestial world remained poorly understood. Over the course of the eleventh century, the wider study of Calcidian astronomy significantly enhanced the comprehension of orderly planetary motion through the simple and careful definition of eccentric and epicyclic models, qualitatively presented. In earlier centuries the knowledge of Calcidius was more limited. In the eleventh century his commentary was widely consulted and known as well as the works of Macrobius or Martianus Capella for serious study of cosmology or astronomy. The introduction of Calcidian material into computus by Abbo of Fleury in the late 900's is one example. The closer study and evaluation of the text of Calcidius itself is another kind of example, testifying to sufficient mastery of Calcidius by a scholar not only to learn from the commentary but also to add to it. In the first part of the eleventh century we encounter such an example, a scholar-copyist who corrected errors, improved descriptions for the sake of clarity, and invented diagrams to enhance the text. We have already met this scholar-copyist because of his work on the diagram for the bounded elongation of Venus in Wien Nationalbibliothek cod. lat. 443, discussed above with Figure 3.²⁹

In this Vienna manuscript of Calcidius's commentary (Vienna commentary hereafter) five paragraphs have received two completely new, one significantly modified, and three fully reconstructed planetary diagrams. With respect to diagrams, at least, the Vienna commentary is by far the most innovative or amended of the whole century. The pedagogical merits of all these modifications are remarkable, although only the three reconstructions, which are replacements for three corrupt traditions, constitute actual corrections of error. The imagination of the designer is pleasing and even challenging at one point. The overall effect and purpose of this scholar's work is to illustrate better—better than the images in any contemporary or previous copy of Calcidius—the regularity of the apparently irregular motions of the planets.

²⁹ Mazal (n. 26 above) has described the manuscript. Both Plato's *Timaeus* and Calcidius's commentary appear in the manuscript at ff. 154r-240v; cc.56-118, the cosmology and astronomy of the commentary, appear at ff. 167r-185r. See Eastwood, 'Heraclides and Heliocentrism', 246-253, for discussion of the correction by this scholar-copyist of both diagrams in Calcidius's commentary for the elongation of Venus; these corrections replace traditional Calcidian images exactly like 2.2 and 2.3 in Figure 2.

The Vienna commentary preserves virtually all the standard diagrams accompanying Calcidius's text of planetary astronomy. Following his description of the celestial sphere and its circles, Calcidius begins to provide the data for mapping the movements of the planets against the background of the celestial sphere. Initially we find the variations latitudinally of the individual planets from the centerline of the zodiac as they proceed from west to east through their orbits (cc.69-70). Calcidius gives no geometrical model for this technically difficult topic, listing instead the number of parts, or degrees, of inclination of each planet's orbit in relation to the ecliptic, or zodiacal centerline. Pliny the Elder did the same, but Pliny's latitudes and Calcidius's latitudes are not the same numbers. Calcidius gives the sun the least variation, no more than two degrees in amplitude. For the other planets he lists: Moon - 12, Venus - 12, Mercury - 8, Mars - 5, Jupiter - 5, and Saturn - 3.³⁰ No diagram exists in Calcidius's text to illustrate this information. As far as we know there was no tradition to do this before the ninth century, when a reformed Carolingian computus included a newly invented diagram for the Plinian latitudes as given in an accompanying excerpt from Pliny that was frequently used in computus thereafter.³¹ Plinian latitude diagrams were used by Abbo of Fleury in his computus and appear in our Figure 2 as diagrams 2.7 and 2.8.

When the director of copying the Vienna commentary came to this topic in Calcidius, he faced a simple choice. There was no Calcidian diagram for the planetary latitudes. There was a widely distributed and somewhat varied tradition of diagrams for Plinian latitudes. The director chose to add a new diagram to the text of Calcidius, and he invented an image, produced by combining the two forms of Plinian latitude diagram (Figure 4). In essence he took the framework of thirteen concentric circles from the circular form and then wrapped the pattern of zigzag planetary lines from the rectangular form around the circular frame. The result in the Vienna commentary looks rough and hastily drawn, although the thirteen circles for the zodiac are done carefully enough. The crude appearance of the result perhaps stems from the lack of any exemplar and only an idea, not a model, to work from. This new figure confronts us as one of two images at the end of the group of paragraphs with data for mapping the planets on the sphere, prior to the

³⁰ Waszink, *Plato*, 117.6-10 (c.70). Pliny's planetary latitudes were: Sun - 2, Moon - 12, Mercury - 8, Venus - 14, Mars - 4, Jupiter - 3, Saturn - 2; see C. Plinius Secundus, *Naturalis historiae libri*, eds. L. Jan and K. Mayhoff, Leipzig 1906, I, 148 (Bk. II, #66-7).

³¹ Eastwood, 'Plinian astronomical diagrams', 157-61, describes the diagrams and their early history. For some of the variations that appeared in the latitude diagrams over time, see B. Eastwood, 'Plinian Astronomy in the Middle Ages and Renaissance', *Science in the Early Roman Empire: Pliny the Elder, his Sources and Influence*, eds. R. French and F. Greenaway, London 1986, 197-251, esp. Figs. 8-10, 14-5, and B. Eastwood, *Astronomy and Optics from Pliny to Descartes*, London 1989, ch. 6, esp. 272-276.

more detailed discussion by Calcidius of how to explain the apparently errant motions of the planets.

The innovation in the Vienna commentary was not a success historically. It appears in this form in no other copy of Calcidius's work that I know. A transformation of it into another diagram, surely inspired by this figure in the Vienna commentary, will be found at the end of a twelfth-century copy of the *Timaeus* with commentary, where the figure is not securely linked to any text in the manuscript.³² Otherwise the novel diagram in the Vienna commentary can be found in two closely interrelated astronomical collections of the twelfth century, lacking Calcidian texts, and preceding a fourteenth-century copy of Cicero's *Somnium* with the commentary of Macrobius.³³ Though surely included for some reason, the diagram has no explicit or obvious connection to a text in any of these last three manuscripts. The design of the Vienna commentary was known but not widely adopted. The designer attempted to create a distinctive figure for the text of Calcidius but reached a less satisfactory solution than earlier scholars had found for the Plinian text. Furthermore the insertion of a diagram here, where none had existed in Calcidius's commentary, was not adopted by subsequent students and copyists of the text.

The Vienna commentary's next novelty was a modification of the traditional figure for the text on the order of the planets (cc.72-3) (Figure 5). This figure followed immediately upon the new image for latitudes, at the top of the next page. Rather than imitate the sort of design commonly found,³⁴ the scholar copyist reduced the information in the image and left it clearer. In the process, he also presented two opposing orders of planets, which gave the results of a Capellan model of planetary motions. Martianus Capella set Mercury and Venus in orbits around the sun, placing them sometimes beyond the sun and sometimes closer than the sun as seen from the earth. Here in Figure 5 those two opposing sequences appear.

For the explanations of solar motion by eccentric and epicyclic models there are intriguing alternative diagrams included as later reconstructions—we cannot say how much later—to correct the traditional figures, which the Vienna commentary preserves. Especially interesting are the diagrams for the eccentric solar model, since they show one or more scholars attempting to produce an adequate figure (Figure 6). Of the four images on the page, the one at the lower left is a commonly found image in early copies and appears

³² Milano Biblioteca Ambrosiana MS E.5 sup., f. 53r (s.XII-2/2).

³³ The diagram appears in the two 12th-century MSS., Hannover Landesbibliothek MS IV.394, f. 33r, and Wrocław Biblioteka Uniwersytecka MS IV.O.11, f. 59r; also in the 14th-century Paris Bibliothèque Nationale MS lat. 6367, f. 1v.

³⁴ An example of the traditional figure is in Waszink, *Plato*, 121.

in the modern critical edition of Calcidius's text.³⁵ We can understand this corrupt image by assuming three steps in its evolution. The initial elements were an enclosing zodiacal circle with the signs equally distributed, two diameters of the circle at right angles to each other in order to divide the zodiac into four equal parts, and an eccentric circle for the sun's path. At this stage the four sections of the solar circle would be unequal and labeled with the various numbers to indicate the time for the sun to pass through each. The second step in development was the insertion of a third diameter, dividing two of the zodiacal quadrants and passing through the center of the solar circle, in order to provide a diameter of the solar circle and to emphasize the position of the center of the solar circle. Following this step the corruption occurred. Copyists unaware of the meaning of the diagram began to change the orientation of the two original diameters of the circle of signs, producing six equal sections of the zodiacal circle; copyists sometimes moved the Greek letter theta from the center of the zodiacal circle to the center of the solar circle as well. In the extant manuscripts of Calcidius from the ninth through the eleventh century, eight other copies have produced the same result seen at the lower left of Figure 6. The lower right image in Figure 6 comes from a similar sort of corruption, the solar circle now being moved to the center. Of the extant manuscripts through the eleventh century, seven produced this resulting image of two concentric circles with six approximately equal divisions. There are three manuscripts from this census group that contain both of these diagrams.

While other types of diagram for the eccentric model also occur in pre-twelfth-century manuscripts, without offering further details we can say that the correct figure for the eccentric model was not easily preserved. How Figure 6 was understood by readers is unclear, but the set of four images suggests a process of evaluation and reconsideration that need not have been unique to this manuscript. In other manuscripts with corrupt diagrams, such as the two lower images here, the process would simply have taken place outside the manuscript, possibly in the dust on the ground as casual commentators have noted, on a renewable dusted board as Martianus Capella recorded, or perhaps incised on a waxed surface or chalked on a wooden surface.³⁶

The process, finding a new image to replace a traditional image that does not assist the reader of the text, was probably carried out within this manuscript very soon after its copying. It is unlikely that a single manuscript

³⁵ Waszink, *Plato*, 129.

³⁶ Augustine, *Confessionum libri XIII*, eds. M. Skutella et al., Stuttgart 1969, 73-74 (IV.xvi.28), remarks on teaching masters drawing logical diagrams in the dust. Willis, *Martianus Capella*, 202.20-3 (VI, 575), mentions the use of a powdered board for calculations. The other examples are found widely.

would be changed successively at different times. The two lower diagrams in Figure 6 derive from traditions of corruption and were copied simply because they existed in the exemplar. The two upper diagrams, presumably added to the manuscript after both text and two corrupt diagrams were in place, indicate exactly the first two steps in the evolution of the solar eccentric diagram described above. The first stage appears in the upper left diagram in Figure 6. The second step appears in the upper right diagram, with a difference being that the line drawn to give a diameter of the solar circle was limited to the solar circle and did not extend beyond it to the zodiacal circle. Otherwise the process is identical, and we can see the placement of the point M, the center of the solar circle, on the diameter NXi of that circle. If not by the original scholar-copyist of the Vienna commentary, this upper pair of diagrams, offering a two-stage reconstruction of the correct diagram here, entered the manuscript almost immediately, analogous to the interlinear entry of corrections to the wording of a text after the copying of the full text has been completed. The final result is not only a correct diagram (upper right) but also a comparison of the correct steps in constructing the diagram with misapprehensions of that diagram. Taken together, the four images show us how the corrupt images could emerge.

The diagram for the epicyclic solar model has a more stable history in the manuscripts and appears here, as in most other manuscripts, in correct form (Figure 7). The only change, notable and helpful, is the smaller, additional figure to the left of the traditional image. Produced by the author of the correction to the solar eccentric model, this kinematical image nicely shows the reader how to imagine the motion of the sun on the epicycle to produce a result equivalent to the prior, eccentric model.

After these new or improved images (Figures 4-7) for planetary latitudes and order and for solar eccentric and epicyclic models, the Vienna commentary offered two further corrections to the planetary diagrams for Calcidius. We have already introduced the first of these in Figure 3, which is the reconstructed diagram for the bounded elongation of Venus with respect to the sun (c.110-11). Because there is a thorough study of these two final diagrams and their construction, a summary will suffice here.³⁷

The initial description in Calcidius's text of the diagram for the bounded elongation of Venus (c.111) is an essentially observational report, placing the observer at X and the circle ABG (reading counter-clockwise) as the zodiacal circle. The sun is seen at B on the celestial sphere, and the two points A and G (Gamma) are points on the sphere where Venus can be seen when at its maximum elongation from the sun. In the manuscript there is a very faded line from X to B, indicating the sight line from observer on earth

³⁷ See the article by Eastwood, 'Heraclides and Heliocentrism' (above, n. 25).

through the sun K to the sun's observed position B; because of its condition we cannot see this line in the reproduction.

Figure 3, with radius XB imagined and the circle removed, is the first of the two intended diagrams for the elongation of Venus. The circle appears in the Vienna commentary's reconstruction, because the last sentence before the diagram, or space for the diagram, proceeds beyond the observational situation and introduces the critical element for a theoretical interpretation. Following the text in the manuscript as far as the space for the diagram, the designer of the new image found a final sentence stating, 'All this will be made clearer, if a circle is drawn through the line XKB and is tangent to the two lines XA and XG, which locate the extent of Lucifer's elongation from the sun'.³⁸ Faithful to the layout of the text, which was set before the copying of the diagrams from the exemplar, the designer included every element described prior to the empty space for the diagram. This included the circle (within the arc XAG), which was added to the initial description and its diagram by Calcidius as the first step in the next diagram. The quoted sentence refers to this. Figure 8, the next diagram in the Vienna commentary, shows the transition. The designer correctly represented the text and gave an adequate reconstruction. For the first of these two diagrams (Figures 3, 8), however, the circle is quite unnecessary, since Figure 3 was constructed to present the observed positions of the planet, not the theoretical explanation by way of an epicycle, which occurs only with Figure 8. With this new diagram—we must remember to include the radius XKB that is now too faded to see—any reader can follow and understand the observational situation, mentally ignoring the circle until the next description.

The peculiarity noted when comparing this diagram with the description in Abbo of Fleury's computus, that is, the location of the letter G to the left and the letter A to the right of the radius XKB, is repeated in the next diagram (Figure 8) as well. A further peculiarity is the later addition of the letters in reversed positions in both diagrams, the letter A at left and the letter G at right. This later addition seems to have resulted from comparison with other copies of Calcidius's commentary, which concur in the latter labeling. Nonetheless the original labeling of Figure 3, with G to the left and A to the right, is correct, since the annual movement of the sun is counter-clockwise and the diurnal rotation is clockwise. Where the composer of the text for folio 37 in Abbo's computus found his exemplar is unknown, but, like Figure 3 from the Vienna commentary, it seems to have been correct.

³⁸ 'Hoc autem fiet apertius, si per XKB lineam circumducatur circulus qui contingat duas a se distantes lineas, id est XA et XG, quae demonstrant modum discessionis a sole Luciferi.' Waszink, *Plato*, 158.5-8, and Wien NB MS 443, f. 182v, 25-28. (The Vienna commentary has one minor error, a 'quod' for 'quae', in this sentence.)

The final correction made by the Vienna commentary is Figure 8, constructed to illustrate Calcidiv's epicyclic model for the elongation of Venus.³⁹ It was described by Calcidiv to explain 'more easily' the limited departure of Venus from the sun. The original lettering in Figure 8 makes only one error. The sun's position, K, is put at the very center; it should be slightly higher, along the radius XKB from the central earth to the observed location of the sun at B. With this small change, we find the epicycle of Venus, DEZH, representing the motion of the planet on a circle with its center on the radial line from the earth through the sun to the zodiacal circle. The sun itself is along the radial line but not within the epicycle of Venus in this model by Calcidiv. Once again the labels on the diagram show disagreement among different medieval scholars with a reversal of the letters A and G as in Figure 3. The correct labeling is the same as Figure 3. The reconstructed diagram for the epicyclic model of the bounded elongation of Venus completed the improvements made to the Vienna commentary, a work of one primary scholar and one or more further scholars. Whether they worked together or separately is unknown.

Concluding remarks

Three copies of Calcidian material, all focused upon planetary motion, show us a much greater importance of the commentary on the *Timaeus* in astronomical study than moderns have previously recognized. The Paris compend demonstrates by the mid-ninth century both an awareness of Calcidiv's distinctive treatment of planetary motions and a conscious concern to extract and disseminate a reasoned account of the appearances of planetary variations in motion.

Abbo of Fleury's computus offers evidence of one further way in which he determined to reform computistical study at the end of the tenth century. His diagrams excerpted from Calcidiv's commentary and the modified accompanying texts from Calcidiv made essential an understanding of the orderly motions of the planets, including a knowledge of the principles of eccentric and epicyclic planetary models. In this way the regularities of the celestial timepieces could be better understood.

Shortly thereafter, early in the eleventh century, the Vienna manuscript of Calcidiv's commentary shows a scholar-copyist and his associates improving upon the illustrations provided by the manuscript tradition. The

³⁹ Waszink, *Plato*, 158-159 (c.112). For this paragraph of Calcidiv, which requires emendation and discussion, see Eastwood, 'Heraclides and Heliocentrism', 240 (translation of c.112), 243 (Fig. 7: corrupt diagram; Fig. 8: reconstructed diagram), 252-253 (discussion of diagrams for c.112).

self-confidence and pedagogical zeal implied by these improvements in the Vienna commentary correspond to a recognition of the importance of clear and detailed comprehension of the diagrams for the text. The selection of diagrams chosen for attention in the Vienna commentary tells us that the rationalized explanation of planetary appearances was of special significance for the scholars involved. Far better than Pliny's doctrine of the causal force of solar rays, the Calcidian models of eccentric and epicyclic motion laid the groundwork for reasoned accounts of planetary variations. These models also provided evidence of the thoroughly ordered constitution of the heavens. Through Calcidian astronomy the regularity of God's creation became more evident.

APPENDIX

Abbo of Fleury, modified texts of Calcidius's *Commentary*
cc. 79-82, 85-92, 110-112, 116, in accompaniment to diagrams on ff. 36v,
38r (Berlin Staatsbibliothek MS Phillipps 1833, f. 37r-v).

This appendix is a complete transcription of the text. Glosses and corrections in the manuscript appear in parentheses as they occur in the manuscript. Lettering for the diagrams uses Roman capitals where they are visually the same as the Greek letters found in the text (and figures) in the manuscript. Where other Greek letters occur I use the following: Th. for theta, Xi. for xi, G. for gamma, D. for delta, Pi. for pi. The appendix is divided into sections numbered, e.g., c.79, according to the paragraphs, or sections, in Waszink's edition (see n. 4 above) in order to indicate the source in Calcidius's commentary of each part of the text in this appendix.

(c.79) Alii speris eccentricis id est que terram intra se contineant quidem sed non ut punctum suum vehi planetas assera(*gl. u*)nt, alii epiciclis potius, hoc est a terra separativis nec imminentibus ei globis.

(c.80) Sit igitur solsticialis eccentricus circulus Th.Xi.H.K. et habeat punctum sub E.Z. ambitum in medietate, scilicet ubi est M. Hoc igitur circulo in cccxv partes et parte quarta unius portionis diviso ad earundem partium exaequationem E.Z. quidem ambitus xciiiS portionibus continebitur, Z.H. xciiS, H.K. lxxx et viii et hora(*corr. i*)s iii, K.E. xc partibus et horis iii. Necesse est itaque ut, cum sol accedit ad E., nobis ex Th. id est terra quasi ex puncto intuentibus super A. tunc ferri videatur cum illa regio non solstitialis circuli sed zodiaci sit multo altioris summitas, ad quam visus noster non potest pervenire. Atque ita per E.Z. ambitum means aequabiliter, qui ambitus tribus ceteris maior est, pluribus ut necesse est diebus maiorem ambitum conficiens ubi ad Z. pervenerit ad B. pervenisse videbitur. Rursus Z.H. peragrato ambitu A.B. ad G. pervenisse creditur. Eodem modo dum transit ab H. in K. videtur transire a G. in D. Similiter dum K. et E. ambitum peragit, a D. in A. transit alienam scilicet zodiaci circuli sumitatem. Quod si solstitialis eccentrici et zodiaci circuli duo puncta iungantur idest M.Th., deinde per hec exeat N.Xi. linea que E.Z.H.K. medietas est M. aequales erunt lineae N.M. M.Xi. Maior igitur est N.M. linea quam H.Th., multo ergo maior N.Th. quam Th.Xi. Cum ergo sol per N. feretur a Th. idest terra elonginquo minor et tardior nobis videbitur. Cum

vero per Xi. proximus terre, maior putabitur et velocior quam illic in quinta semis parte Geminorum. Hic in quinta semis parte Sagittarii creditur.

(c.81) Si ut quidam putant per epicyclos globos sol fertur nihilominus moderatis eum gressibus temperatisque conficere annuos cursus exposita epicyclorum forma docebimus. Epicyclus enim dicitur globus qui per aliquem circulum fertur. Sit igitur zodiacus circulus quem limitant A.B.G.D., solstitialis excludens zodiaci circuli punctum, E.Z.H.K. qui epicyclus intelligatur habens proprium punctum M., et puncto quidem Th. intervallo autem M. describatur circulus M.O.N.Xi. Epicyclus ergo rapiatur cum mundo ab oriente in occidentem raptatu cotidiano, feratur tamen naturaliter contra mundi cursum. Et sol in eodem epicyclo constitutus iuxta totius mundi conversionem moveatur. Quapropter sol, suo epicyclo contrarium motum agens per descriptum M.O.N.Xi. circulum, anni spatio uterque suum conficit cursum. Nam cum epicyclus ab M. pervenerit ad O. litteram, quartam mundi partem obibit et tunc sol ab G. ad K. pergit. Erit ergo sol ubi et littera O. nobis tamen a terra idest Th. spectantibus directa visus acie videtur esse apud notam B. Sicque fit ut cum rursus epicyclus pergit a littera O. ad N., pergat sol a K. ad H., licet videatur esse ubi est G. Rursus idem epicyclus transit ab N. in Xi. et sol ab H. in Z. cum nobis videatur in D. Residuum demum quadrantem idem epicyclus obeat a Xi. in M. et sol a Z. representatus in E. post annum loco suo, videbitur esse ubi est A. et putabitur zodiaci circuli transcurrisse semitam.

(c.82) Qua ratione palam fit etiam secundum epicycli motum ea que videntur nobis aliter quam re abse fiunt videri. Tardior enim et minor visu videtur sol, cum velut in Geminis erit, maximus vero et incitatissimus, cum velut in Sagittario. Estque in solis circuitu maximum intervallum a Th. ad E. idest a terra ad summum limitem solstitialis epicycli, minimum vero ad eiusdem infimum limitem.

(c.85) Sequitur ut, quoniam planete modo stant modo progrediuntur modo retrogradantur per certa signa zodiaci, que causa sit investigari. Sit zodiacus circulus A.B.G.D. cuius punctum est Th., epicyclus autem erraticus cuiuslibet stelle E.Z.H. cuius punctum sit M. littera, per quam velut axem proprium feratur idem epicyclus cum stella in semet locata ab oriente in occidentem. Agantur etiam e regione Th. oblique due linee stringentes utrimque extremos ambitus epicycli Th.Z.B. et rursus Th.H.D. per quem M. epicycli punctum ducatur in altum linea Th.M.A. Ergo stella cum erit in Z. putabitur esse in B., et cum fuerit in H. aestimabitur esse in D., et cum de Z. progreditur ad E., putatur de B. progressa esse ad A. ad precedentia scilicet signa. Cumque non multum spatii a Z. recedet, tamquam in B. diu in eodem loco morari putatur.

(c.86) Sed mathematici mundum et stellas omnes uniformiter secundum naturam suam putant circumferri. Ergo stella cum erit in H. videbitur esse

penes D., et cum H.E. lustraverit ambitum D.A. zodiaci orbis ambitum obisse credetur iuxta signorum sequentium ordinem. Sic stationum, processionum, et regradationum visa patefiunt.

(c.87) His patefactis, ad coetus idest concursiones errantium veniamus. Spera que aplanes dicitur subtus se septem habet speras planetum. Cumque aliquis eorum nobis vicinior obiectus fuerit visui nostro, qui naturaliter in directum porrigitur ne videatur superior, fit ipsius superioris repentina obscuratio et post repentina effulsio. Denique nec luna nec ulla alia stella inferior superiori opposita, ad illam superiorem videndam visui nostro est pervia. Nec mirum cum quidam planetum non solum oppositione sed etiam vicinitate quosdam obnubilent. Nam luna que omnibus est inferior non stella sed terrena umbra diametro a sole distans obscuratur.

(c.88) Ita tamen si utrosque orbes epipedos, idest planos adversum se tam solis quam lune constituas, et ita directa positione ut per centrum utriusque linea que diameter dicitur transeat. Nec solem oculis nostris, licet minor sit luna, subtrahitur, nec lux lune obiectu terre deficit, que, si etiam dimidio momento declinet (*gl.* scilicet a diametro) in aquilonem vel austrum, numquam patitur defectum./ (f.37v) Cur vero non fiat per totum orbem aeclypsis solis uno diei momento? Hinc summitur ratio quia luna utpote minor illi obiecta, si huic climati lucem eius subtrahit, alteri nequit, sicut manifestat pictura. Luna, ut quibusdam placet, minor est quam terra, ut quibusdam maior, ut quibusdam aequalis.

(c.89) Sed cum ignis lucem prebens aequalis erit corpori ex quo emicant umbre. Ipse umbre nascentur in modum chilindri. Utpote sit lucem asserens A.B. quod vero inluminatur G.D., hec quoque aequalia sint et globosa utraque perspicuum est radios, unum A.G., alterum B.D., in directum exaltatos iuxta se esse positos aequali distantia. Merito quia circuli A.B. diameter circuli G.D. diametro equalis est. Idem radii crescant in altum erit A.G.E. radius radio B.D.Z. distans aequali rigore, hoc est sine inclinatione. Et quantumcumque crescant numquam eorum se cacumina contingent E. scilicet ac Z.

(c.90) Sin quod inluminat minus, ut H.Th., quod inluminatur maius, ut K.A., manifestum est umbram cubis K.A. que est K.M. et A.N. in formam quidem effigiari calathi, cuius species crescit in inensum. Nam cum sit maior K.A. diameter H.Th. diametro, profecto tam H.K.M. radius quam Th.A.N. in inensum porrecti latiore, quo plus crescunt, effigiant opacitatem. Sed oportet semper maiorem esse illustrantem globum his que illuminantur. Si itaque lucem advehens prestabit magnitudine, ut Xi.O., ut sit minus quod illustratur, ut Pi.P., utraque autem globosa, in modum coni desinens nascitur umbra in acumen, radiisque porrectis Xi.Pi. et O.P. in altum et contingentibus se invicem apud notam C. Quod fit ex eo, quia Pi.P.

diametros (*sic*) minor est diametro Xi.O., proptereaue umbra species conoides erit.

(c.91) Quia igitur Hiparcus docet magnitudinem solis mille dcccis lxxxix partibus potioiem (*sic*) esse quam terram, terram demum xxvii potioiem esse quam lunam, multoque solem altioiem quam luna sit, apparet umbram terre coni similem effici. Quippe radii solis Xi.Pi. et item O.P. angustant se iuxta diametrum terre Pi.P. et dextra levaque omnia inluminant, terra vero obiecta lumini solis circumfluente se lumine umbram efficit a diametri sui latitudine in angustiam provectam et usque ad finem ultimum angustiarum attenuatam. Quam cum inciderit nocturna luna diametro a sole distans, in tenebras conditur. Porro cum non per centrum solis et lune transit diametra linea, nullam patitur obscurationem, evadens terrenam umbram.

(c.92) Est autem centrum punctus medius circuli, aequaliter undique differens circumducte lineae spatiis. Cumque in eodem circulo ab una in alteram partem plures lineae in transversum possint duci, nulla umquam dicitur diametrus nisi illa sola quae circumulum equaliter dividens recta per medium centrum transit. Essentie gemine partes sunt quas Plato vocat seriem. Hanc enim non materiam neque corpus, secuit, inquit, deus, ut si quis A.B. rectam lineam in longum findat et de sigminibus (*sic*) duobus chi faciat G.D., E.Z., id ipsum incurvet demum et duos innexos sibi invicem circulos faciat H.Th.K.A. et H.M.K.N., hosque ipsos exteriore alio circulo cuius motus conversioque idem semper et uniformis sit circumliget, ut est aplanus, qui ad extra mundi parte oriente videlicet semper eodem modo agit.

(c.110) Ad solis et veneris demonstrationem erit una linea directa ex terre medietate solem demonstrans

(c.111) a littera X. due vero alie dextra levaque nihilominus directe lineae a sole quidem distantes .I. momentis a se autem invicem .c., dextra quidem a parte orientis per X. et A., leva vero ab occidente per X. et G. Zodiacus quoque circulus sit A.B.G. quae singule distant a se momentis .I., et cum sol sit in B. et per X.B. lineam sit punctus solis in littera K. Hec idest X.G. linea prius occidit et prius oritur quam sol, illa vero alia X.A. posterius occidit et et (*sic*) posterius oritur. Necesse est igitur ut littera A. demonstrat Hesperum post solis occasum, G. vero Luciferum pre solis ortum.

(c.112) At vero Plato et alii aliquanto quam solis est elatiorem Luciferi globum astruunt, qui limitatur D.E.Z.H., contingens A. quidem lineam per E. litteram, K.G. vero per H. Cum ergo fuerit in E. Lucifer videbitur esse in A., et cum in H. putabitur esse in G. Cum vero penes D., dubium non est proximum soli videri excelsiorem, et cum in Z. proximum terre humiliorem. Iam illud observandum quod sive ad orientem sive ad occidentem Lucifer secesserit, diebus fere dtis lxxxix iiiior ad id in quo pridem fuerat remeare, et H.D.E. quidem peragrat diebus cccctis xlviiiio ut maiorem ambitum, minorem vero depressioremque reliquis diebus cxxxiii (*sic*) (*recte* cxxxvi).

(c.116) Cum fixo cardine circini casu vel etiam voluntate nostra oppresso aut relaxato circino describuntur circuli tales, ut postremitas circumducte lineae non solum perveniat ad exordium, sed deflectens a competenti rigore infra vel supra circumducta linea sepius artiores laxioresve circulos faciat, hoc genus circulorum spiram vel acantum vel volumen vocamus. Igitur quia planetas sic aplanes rapit cotidiana vertigine, ut non patiaturs eos in eundem locum et velut sedem ex qua progressi fuerant representari, recte dicuntur in spiram et velud sinuosum acanti volumen rotari ob inconstantem atque inequabilem circumvectionem, ut si stella quolibet errans sit in signo Arietis, que ad precedentia signa Piscem et Aquarium provehatur. Contra si remisor erit raptatio, ab Ariete ad sequentia signa, Taurum, Geminos, et Cancrum, recedet, giris deflectentibus ab exordio et e convenienti rigore. Quos quidem giros Greci heliacos appellant, a sole cuius potentiae cedunt planete.

Supersunt due rote quarum altera ostendit planetarum iniquos giros per (post *MS*) absidas, altera quot partes teneant zodiaci vagantes.

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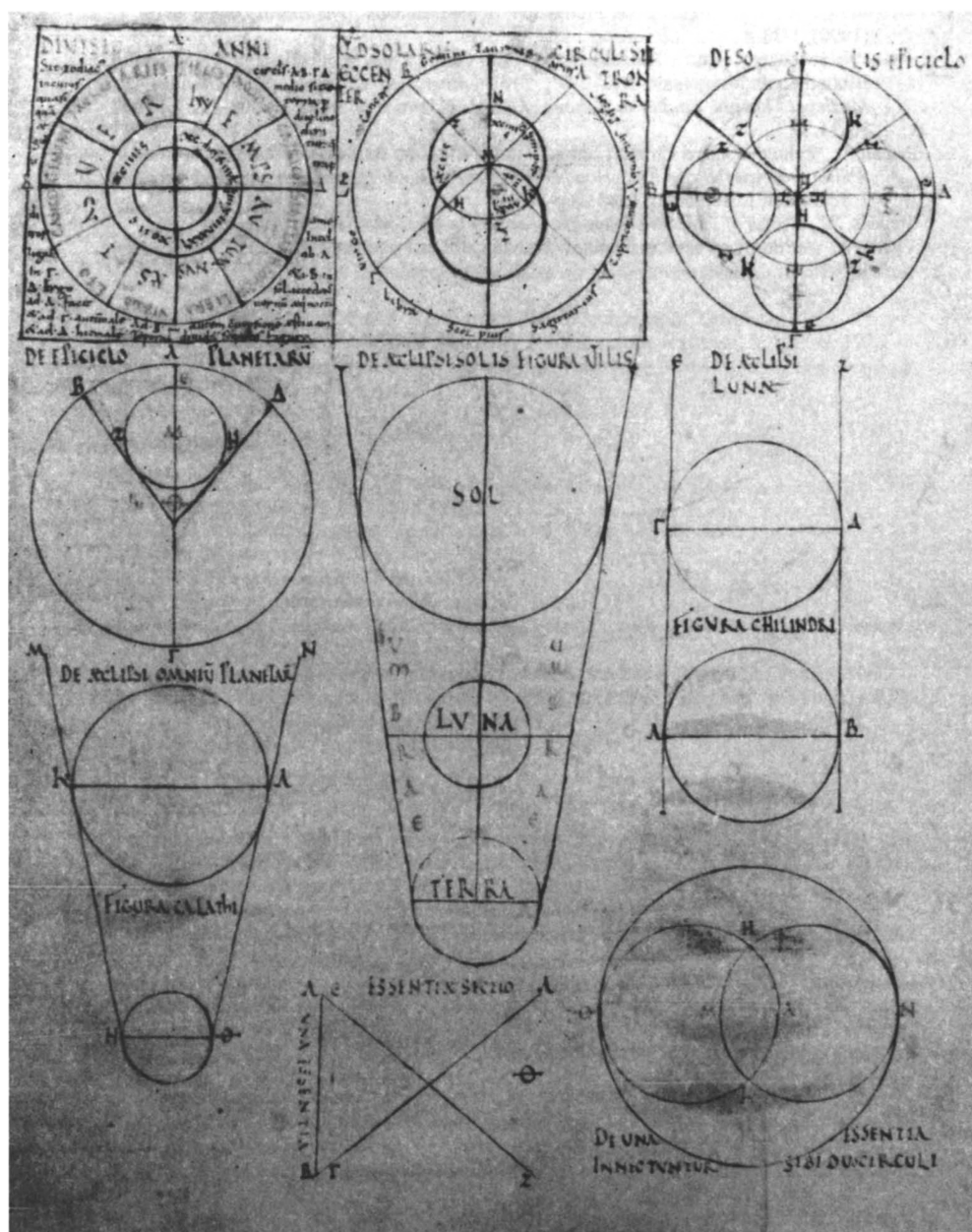


Figure 1 Berlin, Staatsbibliothek zu Berlin - Preussischer Kulturbesitz MS Phillipps 1833, f. 36v: Abbo of Fleury's computus with diagrams (1.1-1.9) from Calcidius.

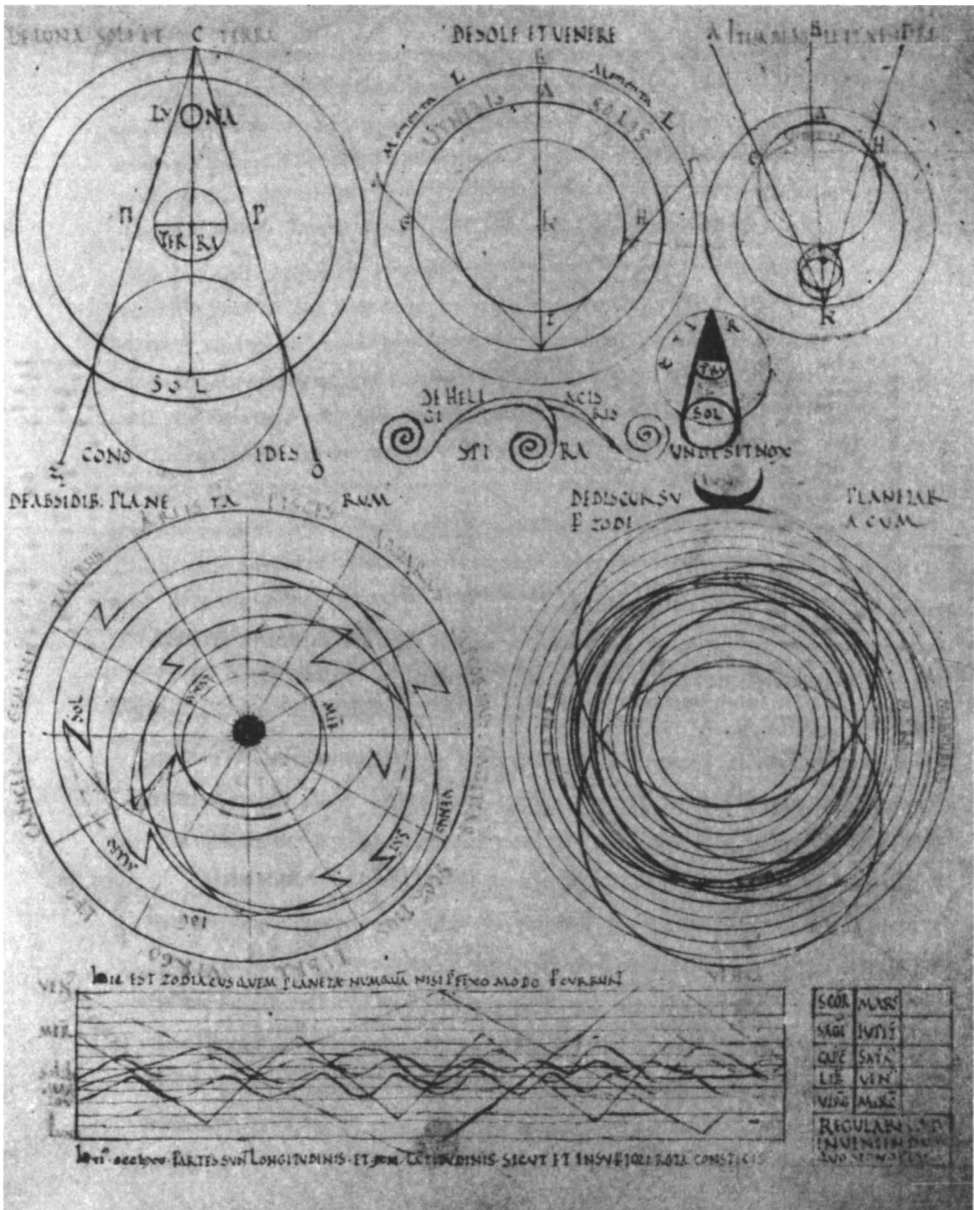


Figure 2 Berlin, Staatsbibliothek zu Berlin - Preussischer Kulturbesitz MS Philipps 1833, f. 38r: Abbo of Fleury's computus with diagrams (2.1-2.9) from Calcidius, Plinian excerpts, and Macrobian excerpt.

Quia super multum cyllonius alma fignat. Metearu videns late splendens cethora.
 Quod si iugis muccus equis soli igneus arbor. Quod si aethereis metar. que deinde
 fignat delectat armipotens fecit fecundus ardor. Quod si excelsu brumula fignat
 fidus. Placcitane cethare septē distimib; quos ad similes. . . . genitor con
 cordi ex animis iustit. Pythagorei dogmatione armonica estare mundi
 celesti aq. distant. A. Egrus acclonatus sibi unice inuallit. inpectu nimio aueloci
 tate inpectus edere sonos musicos. 7. Quod secutus erit ostens. motu quide itellur.
 sonos musicos edere cethare. si ordine collocationu a eunde et dicit. it. it. quippe
 post luna scith altitudinē astra solidat. memorant fabulosa mercurii cōmem
 recensisse lyra. cū celi ascenderet. primis transiēte per que in motu
 planetu adorganici modū psonabunt. ut inuenter lyre simile muru qd
 imago aē inuenter opertū mēlo quoq. repperet. stellari collocatione que
 causi eet cōmentie recensere primū se. astra transmississe lune globū. post
 que superasse solū. Dehinc mercurii stibonit. a ceteroru cū aplari sumā
 a. excelsa. . . . Mathematici tam neq. hanc neq. unā omī ordinatione stellari
 errantiū ponunt. si solē quide post lunā. ultra hunc quidā mercuriū quidā
 aliū aliqū ex residuis collocant. . . . Plato etiā in hoc ipso timēo primū astra
 chne. astra usq. ad lunare circuli. secundū usq. ad solē. liquido dīmenis est.
 etiā in pollicia. ordinationē modo cōmemoratis planetū. si singuloru magni
 tudines. uelocitates. etiā colores. hoc ē splendores ac serenitates. nota. ex em
 celi. hē fu. distitulosq. aem abientes tā ceteros a. uucios polif. quā metho
 tres uerticulis cōp. uant.

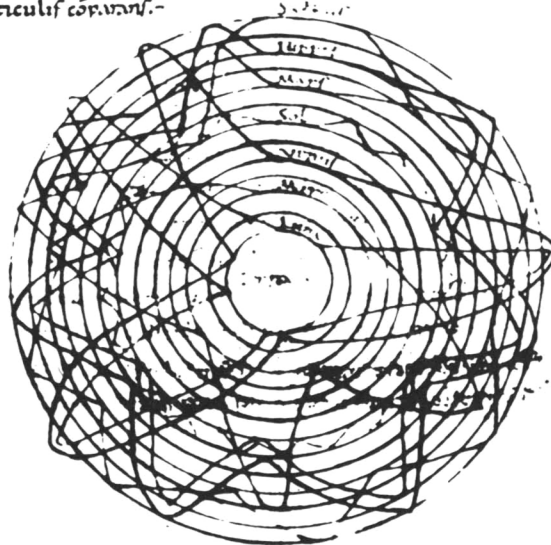
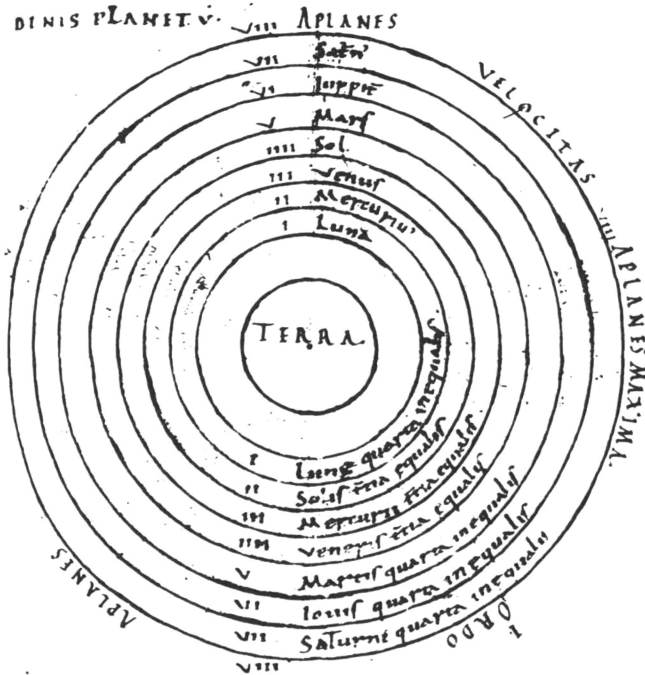


Figure 4 Wien, Österreichische Nationalbibliothek, cod. lat. 443, f. 171v:
 Combined circular-rectangular diagram for planetary latitudes added to
 Calcidius's commentary.

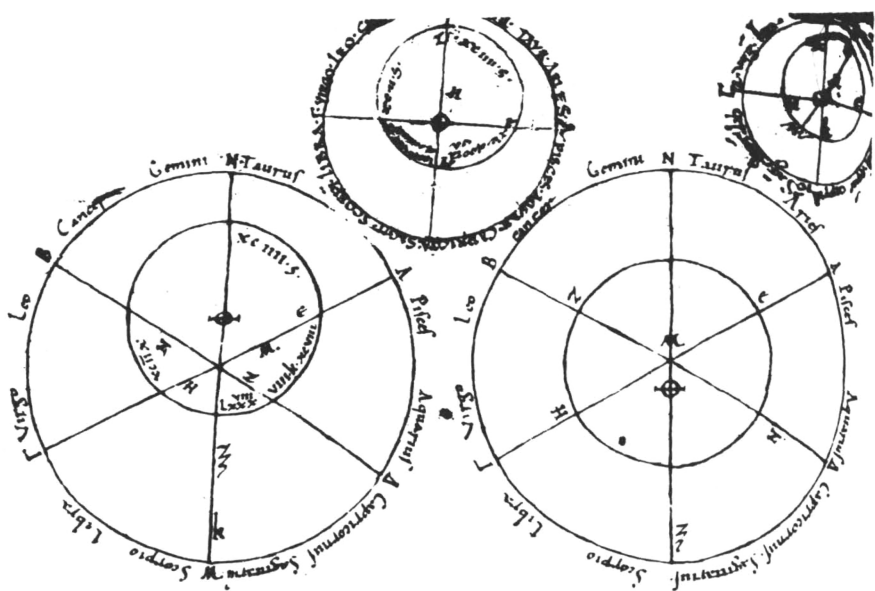
INDICIUM ORDINATIONIS ET VELOCITATIS ET MAGNITUDINIS PLANETARUM.



SUPER EST UT TRACTATUI QUI EST HABITUS DE
 stellis errantibus; illud addat^r quaedam earū sequaces eē. quas appellant hypo-
 lypticas mathematici. ut sol & lunasunt. Hii quippe ignes nūquā adpceden-
 tia signa transitū faciunt. sed adea semp^r que secunt^r. p^rcedant nec subsistunt
 immotū. nec regrediant^r umquā. Alias ū stellas nūnumquā p^rire. nūquā deseri.
 uterere que int^rdu stellas int^rdu redire p^ripso motu vident^r. Et quippe se-
 quacitas visū imaginatioq^r stelle uelud adsequencia signa p^rgentis. atq^r
 ad orientē transeuntis. & acinero ad leonē. statio ū visū & imaginatio
 stelle diu manentis in eodē loco iuxta pl^a fixā stellā nec errantē. p^ro-
 regredatio visū & imaginatio stelle p^rst^rationē quasi ad contrariū rē.
 prioris itineris p^ruectio. & que omā itahien nobis vident^r. sed re absē n^r sciam^r
 ut vident^r. causa uero erroris mōtemplando eae. qd^r cū p^riprios orb^res ferant^r
 seu globos ^{adp}planetes. infraq^r op^rantes orb^ris excelsa nobis eregione terre
 videntib^r. obiectu aeris corporis impediēte aspectū. Lothiacū exterore
 orb^r pagitare uideant^r. & faciendū ergo ut expositis demonstratisq^r errorū

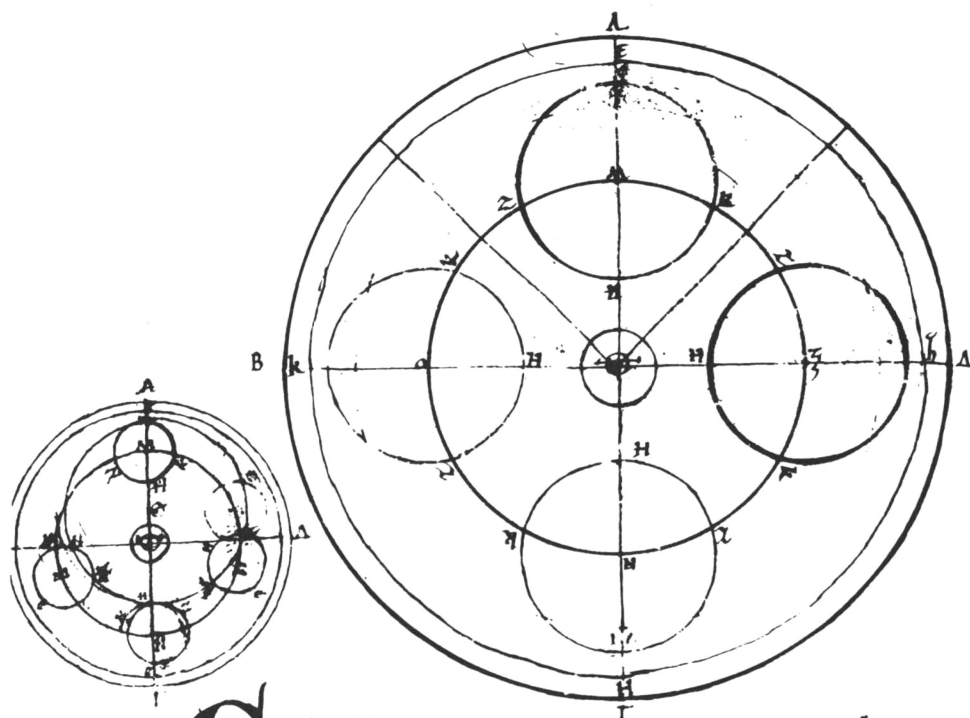
Quid sit sequens
 planetarū. statio
 & regredatio.

Figure 5 Wien, Österreichische Nationalbibliothek, cod. lat. 443, f. 172r:
 Modified diagram for planetary orders according to Calcidius.



ET QUO SOLIS MUTUS INTEMPERIAM FALSO PUTARI
demonstrauimus mecentris circulis. nunc si utquidā putant pericyclos
globos ferre nihil omnino moderatus egressib; temperatq; efficere annuos
curfus deposita pericyclorū forma docebim; . pericyclus d; globus qui
paliq; circulū fertur. sit igit; etiā nunc zodiacus circulus quē limitant
notę . A . B . Γ . Δ . Solstitialis uero . excludens zodiaci circuli punctū .
idē . E . H . H . K . habens ipse propriū punctū . M . et puncto quidē . O . inter
uallō autē . M . describat; circulus . M . O . N . Z . et E . H . K . pericyclus
intelligat; cū uniuersi mundi . terrę ignis rapti similit; ut ceteri ignes
ab oriente in occidentē raptu coacti . ferri tamen naturalit; aduersū
totius mundi uolātū . solq; raptus in eodē pericyclo . constitutus . uota
totius mundi euerfione moueri . Ergo . E . H . H . K . pericyclus pde
scriptū . M . O . N . Z . circulū naturali motu meant; . Etia quā mouetur
totius mundi raptatio . moderate & equabiliter anni spacio cursum
istū conficiat; . solq; raptus in eodē pericyclo . constitutus . pericycli quidē
sui motū . et rariū motū moliat; . mundi uero totius commotū sequat; .
ibit ergo . E . H . H . K . pericyclus . p . M . O . N . Z . circulū gradient; . acū

Figure 6 Wien, Österreichische Nationalbibliothek, cod. lat. 443, f. 174v:
Solar motion according to Calcidius's eccentric model.



EDEM MODO CETERI PLANETES CUM IN GLOBIS CON
 stituti ferantur. per Zodiacum ferri nobis ob supra demonstratas causas videntur.
 tarditatisque & celeritatis id intellectus inerraticus omnibus ratione assequetur.
 licet diuersis temporibus; ceteri nec istis quibus sol cursus suos peragrat. usquado
 utquidam eorum propter nimiam tarditatem interdum consistere. interdum repedare
 videntur. 7 Sol enim minore utpote anniuersarij circuli lustrans. minores
 euagationes tecum exaltat tecum humiliat tecum amectit addiuersas edeli
 plagas deorsum deorsum incurrere nobis uidetur. eamque omnem inceptam anniuersarij
 termino claudit. 7 ceteri planetes quia singillatim unus cuiusque eorum magni
 tudine circulorum quos obeunt & plerumque temporum quibus effecto cursu ad eorundem
 reuertuntur fit reditus ad eorundem. uarias & multiformes motuum editiones
 pati non immerito putantur. 7 Quippe unus biennio ab xii. annis tertius prope
 xxx. orbis suos obeunt. ex quo fit ut uisus noster motus stellarum notans sine intelle
 ctu & recordatione ab eternis stellis. cōpetenti obseueritate circuli puenientis.
 aliarum ut tarditatis quę puenit exemplissimorum orbium pagrationibus; p̄ire

Figure 7 Wien, Österreichische Nationalbibliothek, cod. lat. 443, f. 175v:
 Solar motion according to Calcidius's epicyclic model.

reliquis centū triginta & vi. maxime siquidē discessionis ab occidens adeo
 plapso. hoc dierū numero reuocat. infrequens ueterū uirorū obseruatio
 palam fecit. 7

R

URSUS SUBTEXT

habet. Igitur singulis uniuersis

siq; apto & decenti sibi

motu locatis. uidelicet

hisq; cōsequens erat tēpore

puerit necib; utalibus.

ubi cōstricta corpora facta

animalia unperatūq; didicer

celestia corpora cōstricta utalib;

necib; id stellis animalia facta cō

stiter. & cognouisse q̄ ad ō uidebant. scilicet

ut planetes quoq; in globos p̄p̄os reducti. n̄ solū anima uitaq; fruerent.

si cū scdem omnib; etiā mundū & anima uteret & rationis particeps cēt.

quatenus enī carens q̄d ratione poterit intellegere que iubent. Ca que

diuerse nature motus obliquus p̄directū eiusdē nature motū uertens

semet. utpote cōstrictus circū ferebat. parti maiore. parti minore circulo

rotabant. Etius quidē dimensū spaciū pagentia q̄ minore. tardius uero

que maiore. Diuersa natura quesit sepe iā ostensū ē in superi orib; quodq;

motus eius ab occidente ad orientē ferat. Nec ergo cū sit interior. cōtineat

necessē ab exteriorē orbe qui aplanē d̄r. tarda q; ipsa in p̄grechendo ab

aplanis uelociore rapit ad contrariū motū. & cōphēnsa sequi sequentē.

cōphēndere etiā cōphēndentē uidet. Planetū uero quidā cū cū ali

tardius cursus suos pagent. Merito cōtūlorū enī minorū cōphēnsa aduersū

maiorū anfractū cōparata modicus tēporū inpendiū cūctūlorū spacia

cōplēt. ut luna que uocē cūctūlorū numerū. xx. & vii. dieb; circūlū suū

lustrat. cū saturniū sidus. xxx. p̄pe annis redeat ad p̄fimum exordiū.

Qua de causa fiebat inquit ut exuniformi eiusdē nature cūersione que

cūctū circū ibat. ab his que tardius circū ferebant cōphēndentia

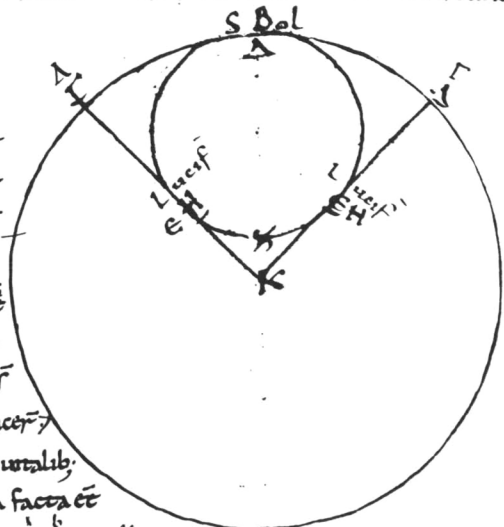


Figure 8 Wien, Österreichische Nationalbibliothek, cod. lat. 443, f. 183v: Calcidius's epicyclic model for Venus.

OWEN GINGERICH

SACROBOSCO ILLUSTRATED

A comparatively modest book of four chapters and about 9,500 words, Johannes Sacrobosco's *De sphaera* was written around 1220 and subsequently reproduced in countless manuscript copies. Eventually, between 1472 and 1656, it went through more than a hundred different printed editions or reprints, making it the most published astronomical textbook of all time. An examination of these books, and especially the way they were illustrated, provides an unusual insight into the way astronomy was taught in the early modern period.

The successive editions of *De sphaera* soon acquired commentaries, at first printed like medieval glosses around the brief original text (Fig. 1), then as an integral part of the book, and finally overwhelming it as in Erasmus Schrekenfuchs's folio edition of 1553 and in Christopher Clavius's *In sphaeram Ioannis Sacro Bosco commentarius* (Rome 1570, etc.). The latter is no longer considered an edition of Sacrobosco but a title in its own right. Nevertheless, *De sphaera* continued to be printed as a separate text, dwindling in proportion and finally being issued in a last, revised Elsevier edition in 1656. Between Renner de Heilbronn's Venetian edition of 1478 (the first relatively common printed Sacrobosco) and the rather anachronistic Leiden Elsevier printing, at least 115 editions appeared. (The most extensive listing is in Houzeau and Lancaster's *Bibliographie Générale de l'Astronomie*, Brussels 1880-89, but I have penciled a dozen more editions into my copy.).

The earliest printed editions had few illustrations. Erhard Ratdolt, a German printer working in Venice, is renowned for the excellence of his typesetting; he printed the finest scientific books of the incunabula period. His 1482 Sacrobosco included two large figures that would become a standard requirement for subsequent editions: an armillary sphere, which he used as a full-page frontispiece, and a schematic plan of the geocentric universe with a simplified nesting of Aristotelian spheres. As was typically the case in the 1400s, Sacrobosco's *De sphaera* was accompanied by Peurbach's *Theoricae novae planetarum*, which, by its very nature, called for diagrams. Ratdolt included hand-colored illustrations of the Peurbachian spheres; these lovely diagrams proved more graphically arresting and hence much more memorable than any of the pictures in Sacrobosco's text. In his

next edition, in 1485, Ratdolt actually printed the color, making the book today a highly collectible item. Not until the late 1480s or the 1490s did printers and editors begin to illustrate some of the technical points raised by Sacrobosco.

Here we shall trace the evolution of the illustrations for two of the concepts discussed in *De sphaera*: first, the argument for the sphericity of the earth, and second, the circumstances for the retrograde motion of the superior planets.

Aristotle, in *De caelo*, argued from archetypal reasons that the earth must be spherical. Because he believed that the terrestrial element earth was heavy (as opposed to the weightless quintessence composing the heavens), he assumed that each part of the earth would press down toward the center, resulting in a spherical body. If the earth had come into being, it must have grown in the form of a sphere; if it is ungenerated and everlasting, he declared, it must be the same as if it had developed as the result of a process. Then, seeming almost as an afterthought, he added two pieces of observational evidence. He first pointed to the shape of the earth's shadow on the moon during a lunar eclipse. Finally, he remarked on the way stars change their position as travelers venture north or south.

Five centuries later, writing in the work we now call the *Almagest*, Ptolemy went straight to the observational arguments. A lunar eclipse is seen at the same moment by all observers, yet the position in the sky is different for more easterly or westerly observers. Furthermore, as we travel toward the north, some of the southern stars disappear. Together these observations prove the earth's sphericity 'in all directions'. As an extra fillip he notes that from a ship sailing toward a shore, a mountain will gradually rise up from the sea as if it had been submerged.

Sacrobosco succinctly encapsulated Ptolemy's first argument (that the earth is spherical in an east-west direction) in just four sentences, and the second in nine more, remarking, 'But the earth seems flat to human sight because it is so extensive.' Like Ptolemy, Sacrobosco then added the observations made at sea, but he is clearer, specifically citing the difference in the view from the top and the bottom of a mast. When the first well-illustrated *De sphaera* appeared in Venice in 1490 (or possibly in an edition of 1488), each of these three arguments was illustrated, in a pattern that was to become *de rigueur* for the next several decades (Fig. 2). Apparently the ship was a special favorite of the illustrators, for from the beginning it was an elaborately rigged vessel with a mandatory crow's nest.

Amazingly and amusingly, the figure with the ship underwent some unexpected metamorphoses. In 1501 the prolific Venetian printer G. B. Sessa published an edition of *De sphaera* that was essentially a plagiarism of Ottaviano Scoto's beautiful Venetian edition from a decade earlier, but the

crude reproduction of the ship completely missed the point. The view by the sailor on the deck is no longer blocked by the curvature of the ocean, so both he and the watchman in the crow's nest share the same unobstructed sight lines! (Fig. 3). Even more absurd is the diagram in the Italian edition presumably overseen by the well-known Florentine astronomer Ignazio Danti (Florence 1579). There the ship appears in full glory, but unfortunately the sea is completely flat, so that the diagram fails to convey the whole point of the exercise (Fig. 4). In sympathy we should note that even today authors frequently lose control of the illustrations added to their works, and perhaps Florence in 1579 was no exception!

Meanwhile, a happier development took place north of the Alps. In 1531 Joseph Clug, one of several printers supplying textbooks for Wittenberg University, brought out a pocket-sized edition of *De sphaera*, apparently small enough and cheap enough that nearly every student of the quadrivium could afford his own copy. While not encumbered with a commentary (which was presumably supplied by the lecturers), it did have a substantial preface by the Martin Luther's education lieutenant, Phillip Melanchthon. This was the first of Wittenberg editions that ran in a succession for ninety years, always including the Melanchthon preface. Within months of its first printing the handy little version, with its preface and illustrations, was pirated in copy-cat detail in Venice, and soon afterward in other centers of printing. (Shortly thereafter Melanchthon's name went onto the *Index librorum prohibitorum*, but this did not prevent Italian publishers from using the preface; they simply omitted his name!)

Perhaps to steal a march on the international competition, in 1538 Clug introduced a new element into the illustration of Sacrobosco's arguments for a round earth, namely, the addition of moving parts, the so-called volvelles. In this he or his advisors were following the lead of Germany's most prolific maker of paper instruments, the Ingolstadt professor Petrus Apianus, who had introduced one of these volvelles among the several found in his *Cosmographia* (Landshut 1524 and numerous subsequent editions). The 1538 Wittenberg edition of Sacrobosco included three pages with sets of volvelles, and these were copied faithfully without further elaboration in editions published in Venice, Paris, Antwerp, and elsewhere. Generally the volvelles were supplied on a separate piece of paper, and it was up to the buyer to assemble them in proper order (Fig. 5). Eventually some editions included, within the book itself on pages backed by text, the pieces to be cut out for the volvelles. Needless to say, no owner was willing to sacrifice the text itself to assemble the explanatory devices.

Two of the three volvelle assemblies related to the pair of basic arguments for the roundness of the earth. The first, dealing with the east-west curvature, included a fixed geocentric reference frame, a movable

eclipse, and a second movable horizon. Thus the altitude of the eclipsed moon could be compared and contrasted between two horizons separated in longitude. The second, dealing with the north-south curvature, showed the northern stars and featured both a fixed horizon and one movable in latitude, which clearly demonstrated the variable height of the celestial pole. This second device served double duty, because it also showed lines schematically for the sun's daily movement, high in the summer and low in the winter (Fig. 6). The moving part carried the adage *Nulla dies sine linea*. This must have created great amusement among the Wittenberg schoolboys, who would have known the proverb 'No day without its strokes' from various sources, including Erasmus's *Adagia*. Erasmus cited it from Pliny, who related a splendid fable about the ancient Greek painter Apelles. That master artist, they were told, made it a policy never to let a day go by without painting a line.

The third set of volvelles, incidentally, illustrated the concepts of acronychal and heliacal risings or settings, a useful auxiliary to Sacrobosco's third chapter, which dealt with poetic allusions to the stars and planets. As for the ship, it was not seen as amenable to volvelle treatment, so it continued as a normal illustration well into the seventeenth century. Beginning with the Wittenberg editions, however, the ship and shore were depicted totally out of scale on an entire globe.

It is perhaps worth remarking that two groups of editions were characterized by *not* including a picture of the ship. These were the quite beautiful folios from the press of Simon Colines in Paris in the 1520s and 30s, and the seventeenth-century Elsevier octavos. It was almost a requirement, however, that each *De sphaera* should actually show a sphere, and also the layout of nested Aristotelian spheres, and while these had shrunk almost to mere decorative medallions in the class of Wittenberg octavos, they became major artistic classics in the Colines editions. Otherwise these typographically superb productions had only very sparse illustrations. Someone clearly rethought the illustrations for the little Elsevier Sacroboscus from Leiden, for there is a freshness about them in contrast to the time-worn and weary diagrams that had been reprinted throughout Europe for so many decades—but more of this later.

De sphaera's fourth chapter considered the motions of the planets, but only very superficially. One topic was the retrograde motion of the superior planets, which in the Ptolemaic arrangement was modeled with an epicycle. As Figure 7 shows, the retrogression occurs when the planet is on the closer arc of the epicycle and is being turned effectively backward. (This figure, incidentally, is *not* from a Sacrobosco, but from an incunable edition of Aristotle, Lyon 1500). The diagram, however, contains a highly misleading error. Because the center of the epicycle is also in motion, the planet will not

come to a stationary point when the line of sight is tangent to the epicycle. At this juncture the planet still shares the forward motion of the epicycle itself, and the balancing of the forward motion of the epicycle center with the backward component of the epicyclic motion will not occur until somewhat later in the cycle. In fact, if the forward motion of the entire epicycle is fast enough with respect to epicyclic motion, retrogression will not occur at all. This is the situation with respect to Ptolemy's lunar theory, where the moon has a slow-turning epicycle and never retrogrades.

Beginning in the 1490s, the editions of *De sphaera* illustrate the retrogression quite incorrectly, but the blame lies not so much with the illustrators as with Sacrobosco himself, whose text is very clear in describing precisely the erroneous configuration. But somehow we feel that the thirteenth-century astronomer perhaps knew better, because he does add, 'But the moon is not stationary, direct, or retrograde because of the swiftness of its motion in its epicycle', even though the non-retrogression is produced by the slowness of the motion in the epicycle rather than by its swiftness. Be that as it may, although commentators added brief clarifications, the figure persisted in the main stream of editions right up into the early 1600s. Christopher Clavius, who reproduced the entire Sacrobosco text piecemeal in his 500-page commentary of 1570, at least suppressed the figure and gave a correct explanation, although in none of his editions did he ever attempt a corrected figure. However, the handsomely designed Elsevier editions finally showed a corrected figure for the stationary points and retrogressions (Fig. 8), part of a fairly thorough overhaul that updated the book while preserving most of the original text.

This error is particularly beguiling because in the Ptolemaic system it is closely related to the observational problem of establishing the size of the epicycle. In looking at the static diagram, one is tempted to suppose that an observation made near the tangential point would serve best in establishing the size of the epicycle, and at first it appears odd that Ptolemy uses two very close-spaced observations for Mars, one made at opposition on 27 May AD 139 and the other only three days later on 30 May, to establish the epicycle size. However, in the dynamical situation with the combined motion of the epicycle on its deferent (carrying circle) and the planet in the epicycle itself, it is velocities that matter, and Ptolemy cleverly chose the observations so that the projection foreshortening is minimized. In other words, he understood exactly what he was doing.

The longevity of *De sphaera*'s use as a textbook demonstrates, in the first instance, the inherent conservatism in astronomy teaching throughout the fifteenth and sixteenth centuries. To be sure, the associated commentaries and ancillary guides changed somewhat. Such guides included Hartmann Beyer's *Quaestiones novae in Libellum de sphaera* (Frankfurt 1549, etc.)

and Sebastian Theodoricus's *Novae quaestiones sphaerae* (Wittenberg 1564, etc.), which both used the familiar set of three volvelles. An examination of *De sphaera*'s illustrations, however, shows two distinct periods in its printing history. From around 1480 to the addition of the Wittenberg volvelles in 1538 there were six decades of experimentation and development in the best ways to present Sacrobosco's elementary exposition. Clearly this text was a live force in astronomy education. But from 1538 on, and especially after the addition of Élie Vinet's commentary in the 1556 Paris edition, the presentation of *De sphaera*'s text became essentially fossilized. The same illustrations, and often the very same woodblocks, were continually recycled.

Even today, quaint as parts of Sacrobosco's text sound, the concise and clear explanations can still inform students of the rudiments of spherical astronomy. Yet the stranglehold that Sacrobosco's text seemed to bear over astronomy education suggests that innovation was no longer encouraged in college astronomy teaching. Even as distinguished a teacher as Christopher Clavius felt obliged to disguise his text as a commentary on Sacrobosco. First published in 1570, it underwent frequent revisions, and Clavius's last edition in 1611 even includes a mention of Galileo's new observations. Meanwhile, the Wittenberg form continued to be printed even as late as 1629, in a version essentially indistinguishable from that of 1538, except in two respects: the 1629 edition has two minor interpolations, and the world map on its globe is far inferior to the earlier one. In 1626, in a last attempt to fan the dying embers, Franco Burgersdicius issued the emended and re-illustrated Elsevier text mentioned earlier; it included brief material from Peurbach's *Theoricae novae planetarum* to make up for Sacrobosco's weakness in that area. The text, apparently serving schools in Holland and West-Frisia, went through four more editions, the last in 1656. With that, Sacrobosco's book went into a long slumber until it was briefly aroused by Lynn Thorndike's unillustrated edition and English translation (Chicago 1949).

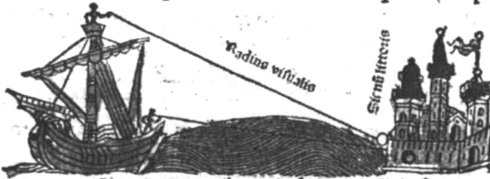
The incunables are now, of course, expensive collector's items, but the sixteenth-century copies, often quite uncommon because they were worn out by generations of undergraduates, have been relatively cheap. 'Don't buy Sacroboscus,' a New York dealer has warned me, 'They are a drug on the market.' Nevertheless, I have found them a fascinating window into the generally rudimentary, but often ingenious, level of early astronomy teaching. And I have about thirty of them on my shelf, not counting Clavius.

SPHAERAE

QUOD aqua sit rotunda &c. Supius ostendit autor terra esse rotundā; in ista parte pbat aqua esse sphaericā figurā. Et diuidit ista pars in duas. Nā in prima pbat aqua esse rotundā per signū; in secunda per rationē. Secūda ibi. Itē cū aqua sit corpus &c. Prima pars posset diuidi sed nō cū ro. Dicit de priā parte q aqua sit rotunda patet: ponat signū dicit ipse in littore maris: & recedat nauis: & portus: & intm elonget q oculus illius qui stat in pede arboris nō uideat signū quiescēte nauī octu. hū illius qui stat in sūmitate nauī bene uidebit illud signū. Sed oculus existens in pede mali uel de-

Quod aqua sit rotunda.

QUOD aī aqua habeat tumore & accedat ad rotunditatē sic patet. Ponat signū i littore maris: & exeat nauis a portu: & intm elōget q oculus existēs iuxta pedē mali nō possit uidere signū. Stāte ue ro nauī oculus eiusdē existētis in sūmitate mali bñ uidebit signū illd. Sed ocul⁹ existētis iuxta pedē mali melius deberet uidere signū q qui est in sūmitate: sicut patet p lineas ductas ab utroq; ad signū: & nulla alia huius rei cā est q tumor aquae. Excludant. n. oīa alia ipedimēta: sicut nebulae & uapores ascēdētēs. Itē cū aqua sit corp⁹



homogeneū totū cū partibus eiusdē erit rōnis: sed partes aq (sicut i guttulis & roribus herbarū: accidit) rotundā naturalr appetūt formā: ergo & totū cui⁹ sunt partes.

Quod terra sit centrum mundi.

QUOD autē terra sit i medio firmamenti sita sic patet. Existētib⁹ in superficie terrae stellae apparet ei⁹dē q̄tatis siue sint i medio coeli: siue iuxta ortū: siue iuxta occasum: & hoc q̄a terra aequaliter

gnūm demonstratiūm: & in secunda per signū deducens ad impossibile. & in tertia ostendit de quantitate terrae esse nullā respectu coeli. secūda ibi. Si terra magis accederet. Secūda incipit. Illud idē &c. Dicit de prima parte q terra sit in medio. Patet per hoc signū quia stellae siue sint i ortu siue in occasu siue in medio coeli apparent ei⁹dē quantitatē existētib⁹ in superficie terrae. Et hoc est q̄ terra aequaliter distat a coelo. Iuxta quā partē debetis intelligere q terra stat in medio. tribus de causis. Nā ut alias dixi uobis q quattuor sunt planetae qui tenēt quattuor elemēta in forma. Nam ignis tenet aquam. Mercurius tenet aerem. Mars tenet ignem. Saturnus terram. Nam cum Saturnus sit frigid⁹ & sicca complexiois effectiue inspiat alia elementa suis radiis: qua parte expiata uirtute radiorū apponitur terrae apposita comprimit aliam partē terrae: ut moueatur ad medium. Et cum medium sit immobile: ideo terra est in medio immobilis. Alia est causa: ut finalis peracta a toto coelo. Nam terra remota a uirtute primae naturae siue primae essentiae: ideo nō potest participare nobilitatem primae essentiae per motum: sed potius per quietem. Idcirco est quies & status oīum quae in ipsa sunt. Et istae sunt rationes quae redi possunt in lumine naturae. Sed alia est ratio ueritatis: quia deus qui fecit coelum & terram & omnia quae in eis sunt posuit terram in medio fixam ut coelū uolueret circa ipsam motu suo: ut dicit propheta. Firmavit orbem suum: quomodo commouebitur ut coelū & stellae uoluerent circa ipsā motu suo. Vñ diuina sustēta potētia in medio uelut pīd⁹: ut scribit theologice. Ne timeas me ait deus: q̄a suspēdi terrā in funiculo fundatā. ē. n. supra stabilitatē suā.

b iii

Figure 1 Sacrobosco's text surrounded by the commentary of Cicchus Aesculanus in this Venice, 1499 edition. (All illustrations in this article from the author's collection.) Reduced to 66%.

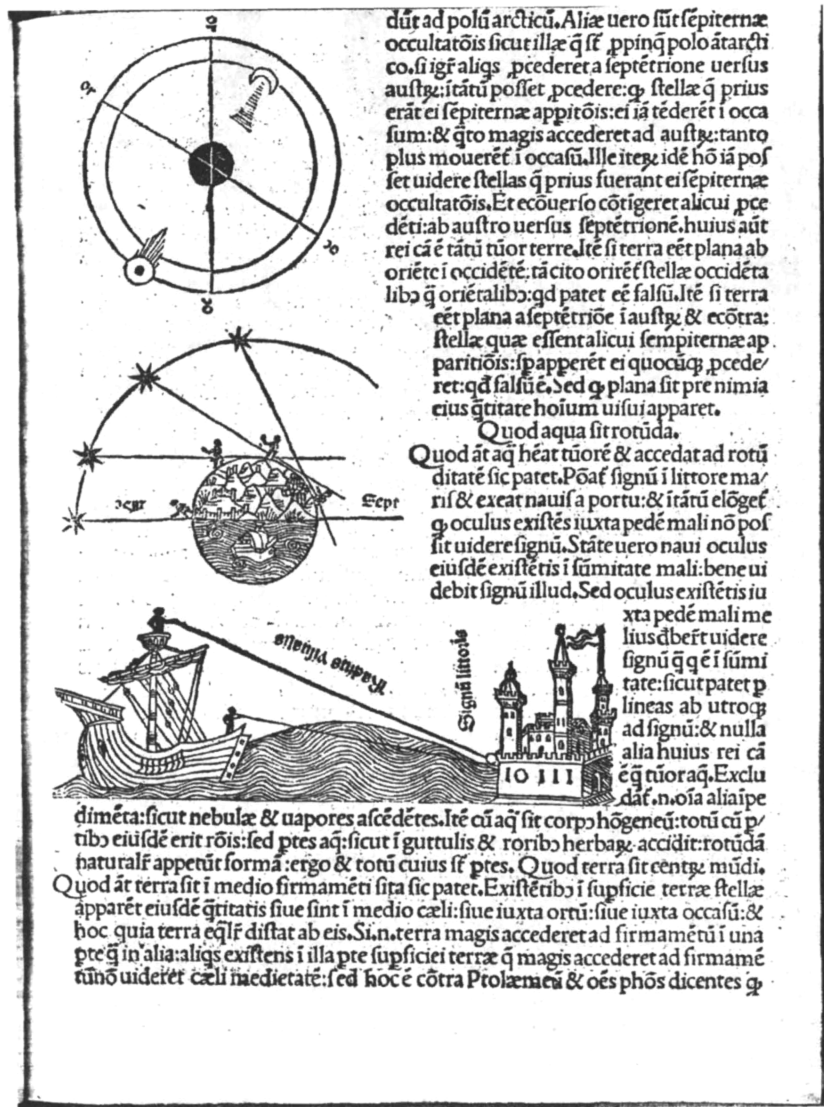


Figure 2 The arguments for a round earth in the first well-illustrated Sacrobosco printed by Ottaviano Scoto, Venice, 1490. *Reduced to 75%.*

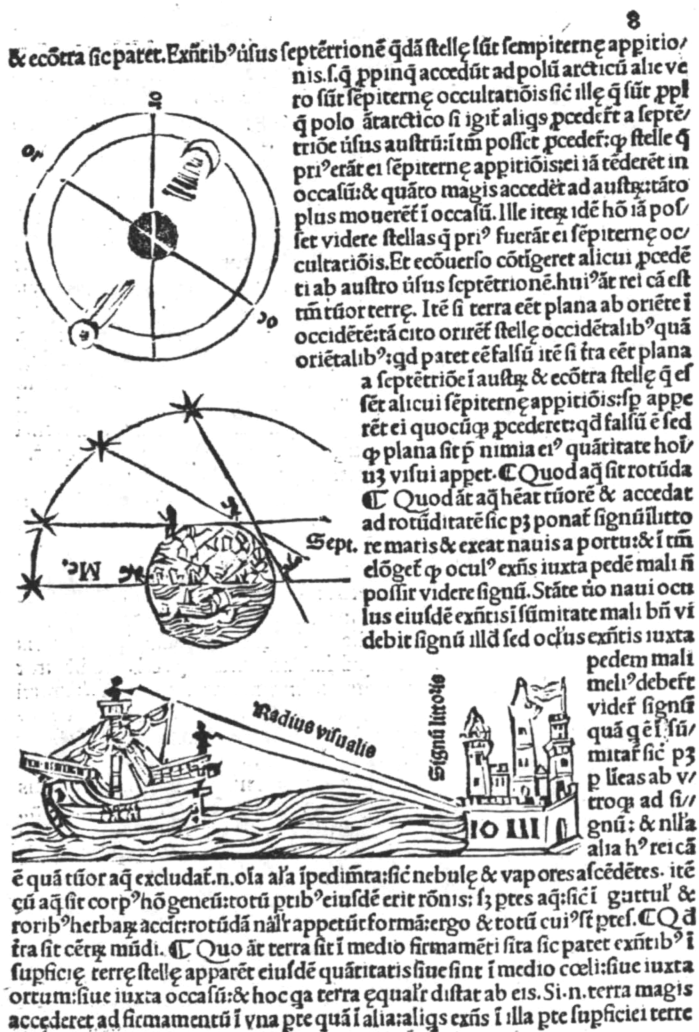


Figure 3 The sight lines from the ship are clearly defective in this edition printed by Jacopo Pencio de Leucho for M. Sessa in 1519, essentially a duplicate of the edition printed by Sessa's brother in Venice in 1501. *Reduced to 75%.*



Figure 4 In the Florence, 1576 Italian translation, the sight line seems to argue for a flat earth! *Reduced to 85%.*

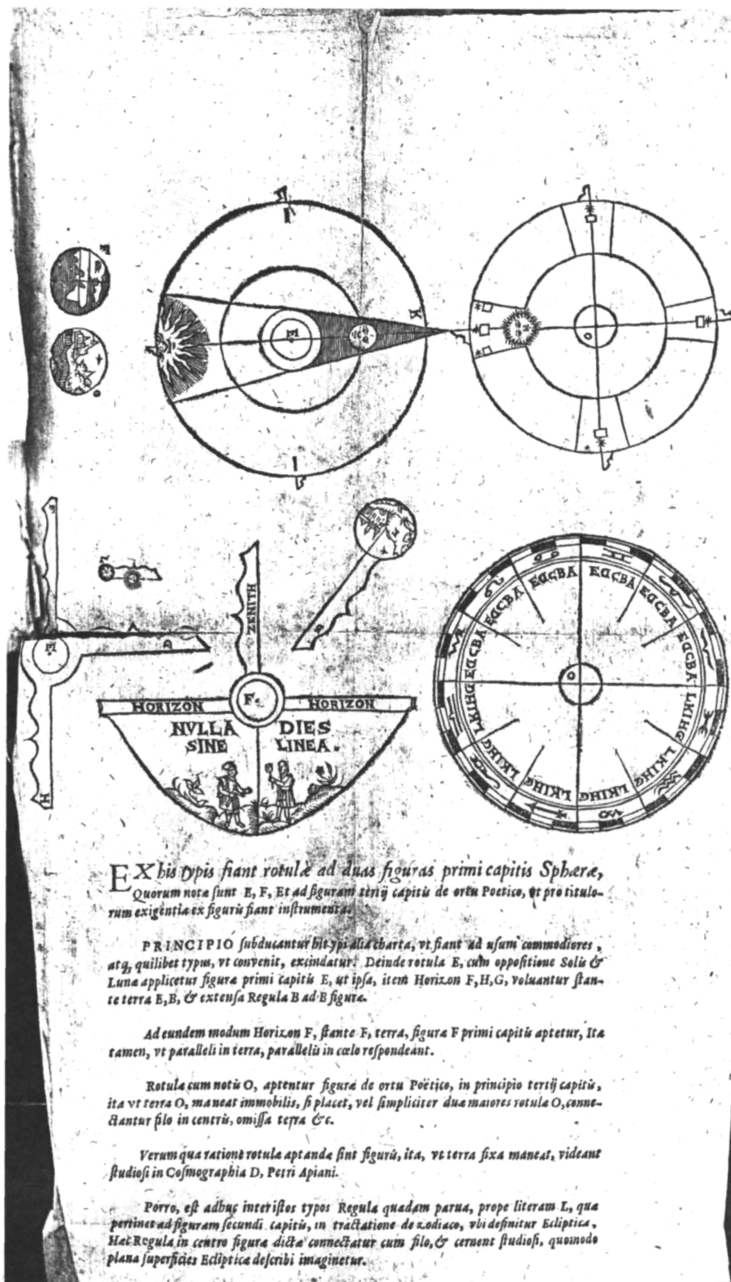


Figure 5 The sheet of uncut volvelles belongs to the very late Wittenberg, 1629, edition of *De sphaera*. Not all of the 18 lines of explanatory text are reproduced here. *Reduced to 55%.*



Figure 6 The second of the three standard volvelle assemblies introduced in Wittenberg in 1538; the Wittenberg edition shown here is from 1558. *Actual size.*

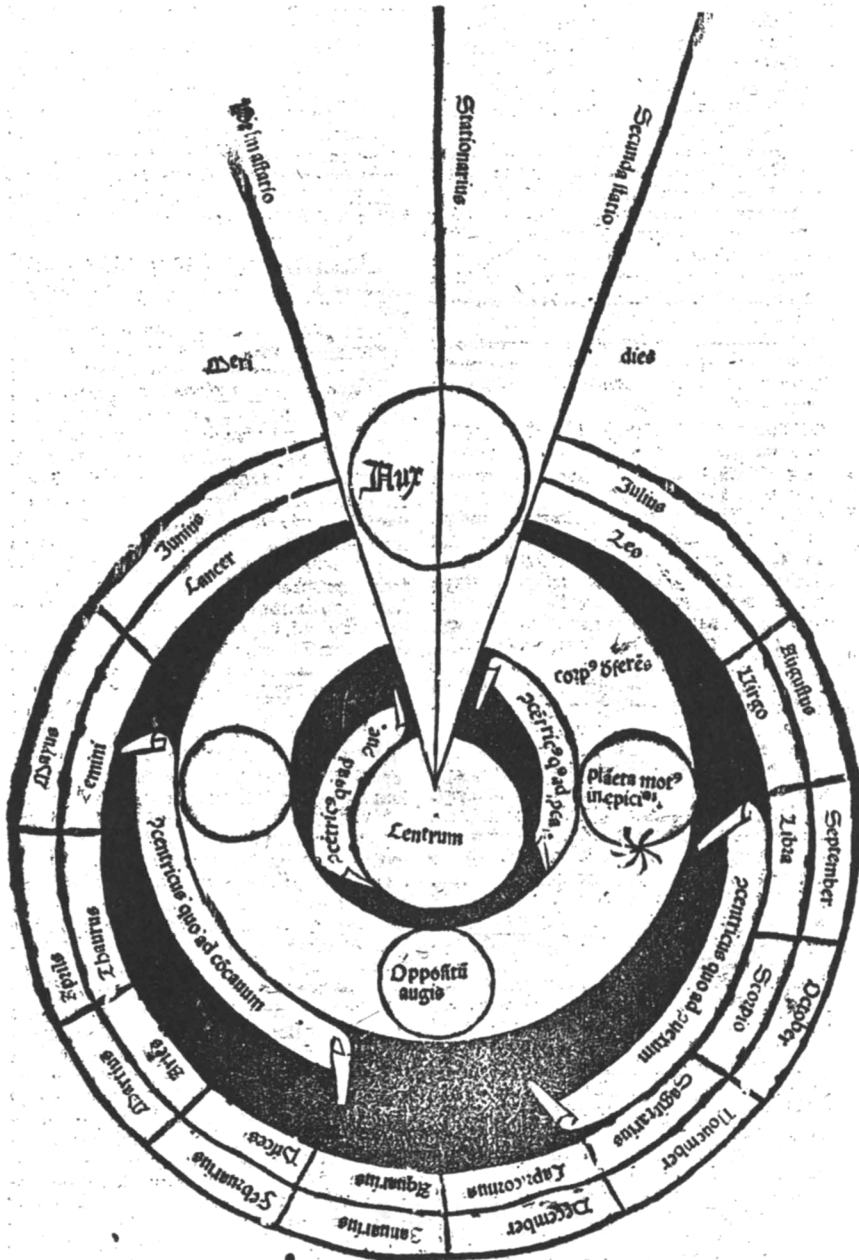


Figure 7 A diagram showing erroneously that a planet becomes stationary when the sight lines are tangent to the epicycle appears in the Lyon, 1500, edition of Aristotle's works. *Reduced to 90%.*

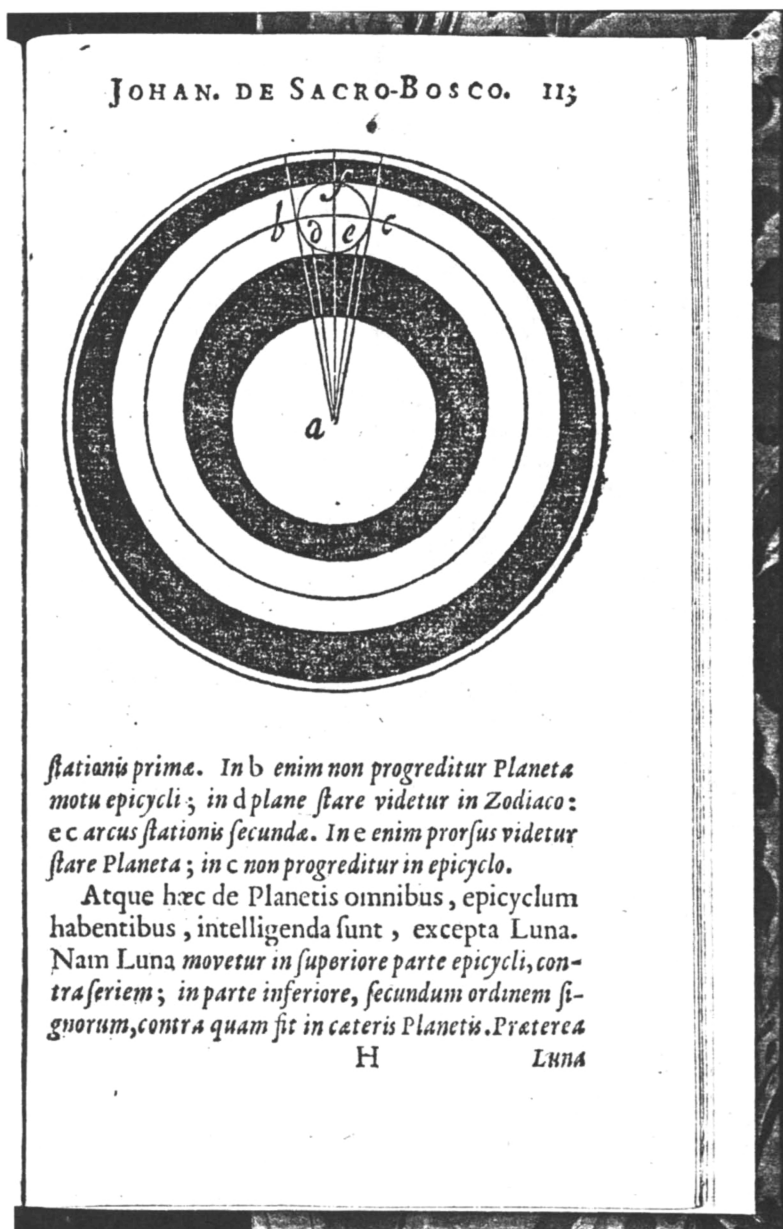


Figure 8 The seventeenth-century Elsevier editions of the revised *De sphaera* text have finally corrected Sacrobosco's statement that a planet will go into retrograde motion when the sight lines are tangent to the epicycle (*b* and *c* in the diagram); the retrogression will actually occur between *d* and *e*. *Actual size.*

BERNARD R. GOLDSTEIN

ASTRONOMY IN THE MEDIEVAL SPANISH JEWISH COMMUNITY

Spain was unusual in the Middle Ages as a meeting ground for Muslims, Christians, and Jews. In particular, it is now customary to look back to a 'Golden Age' of Jewish culture from the tenth to the twelfth centuries, partly under Muslim domination and partly under Christian domination, although in that period the Jewish community faced real crises. Nevertheless, the Jewish elite was more integrated into the dominant culture in Spain than anywhere else in the Middle Ages. Indeed, Samuel Ibn Nagrela (d. 1056) became vizier of Granada and led a Muslim army and, as *nagid* (head of the Jewish community), he was a patron of learning in addition to being a scholar and poet in his own right—in general, his actions and interests paralleled those of a model Muslim ruler, making due allowances for the minority status of Jews.¹ For these elite Jews to serve in the government under Muslim rule, they had to be thoroughly conversant with the secular aspects of Muslim culture such as Arabic literature, philosophy, and science. But the mark of this elite was also to excel in matters of Jewish culture, particularly Hebrew poetry. And this Hebrew poetry was modeled after Arabic poetry in rhyme, meter, and theme, but using the Hebrew Bible as the store of images rather than the pre-Islamic poetry used by Muslims.² The result for the Jewish community was a creative assimilation of aspects of a foreign culture that is quite impressive.

The reconquest of Muslim Spain by the Christians began in earnest with the capture of Toledo in 1085, leading to the entry of fanatical Muslims from North Africa who were, in general, hostile to the Jewish community. By the middle of the twelfth century, most Spanish Jews were living in areas dominated by Christians, and by the middle of the thirteenth century, most of Spain (with the exception of Granada) had come under Christian control.

¹ For a history of the Jews in Muslim Spain, see E. Ashtor, *The Jews of Moslem Spain*, 3 vols., Philadelphia 1973-84. For Samuel Ibn Nagrela as the model for Spanish Jews, see G. D. Cohen, *The Book of Tradition*, Philadelphia 1967, 269 ff.

² A. Schippers, *Spanish Hebrew Poetry and the Arabic Literary Tradition*, Leiden 1994. For a Hebrew poem from eleventh century Spain with an astronomical theme, see R. Loewe, 'Ibn Gabirol's Treatment of Sources in the *Kether malkuth*', in *Studies in Jewish Religious and Intellectual History Presented to Alexander Altmann*, eds. S. Stein and R. Loewe, Tuscaloosa 1979, 183-94.

But Spanish Muslim culture cast a long shadow, and it affected the Jewish community until the expulsion in 1492.

The twelfth century

The medieval Hebrew tradition in astronomy began in Christian Spain in the twelfth century with Abraham Bar Ḥiyya who mainly summarized Arabic astronomical texts. Bar Ḥiyya was soon followed by Abraham Ibn Ezra, and together they laid the foundation for this Hebrew tradition that spread far beyond the Iberian peninsula. To be sure, one should also consider Maimonides a product of twelfth century Spain despite the fact that most of his works were written in Egypt, for he spent his formative years there, and refers to discussions of astronomy by Muslim scholars in Spain.

Bar Ḥiyya's astronomy is much indebted to al-Battānī. 929), an astronomer at Raqqa on the upper Euphrates (now in Syria). Al-Battānī produced a set of astronomical tables, called a *zīj* in Arabic, that in turn was based on Ptolemy's tables with some modifications. However, Bar Ḥiyya transformed those tables of planetary motion for the Jewish calendar, rather than the Seleucid calendar used in the original. Bar Ḥiyya's introduction to the tables appeared in a separate treatise, *The Book on the Calculation of the Planetary Motions*, and it too is heavily dependent on al-Battānī's work.³ In fact, al-Battānī gave a rather good account of Ptolemaic astronomy, and so Bar Ḥiyya chose well. In any event, from that time on, a reader of Hebrew had reliable access to the basics of planetary motion. Levi ben Gerson (d. 1344), the most original medieval astronomer to write in Hebrew, repeatedly mentions the tables of al-Battānī as representing Ptolemaic theory even though they had not been translated as such before his time into Hebrew and there is no persuasive evidence that Levi read Arabic. Therefore, I assume that Levi is referring to Bar Ḥiyya's version of these tables even though Bar Ḥiyya himself did not call attention to his dependence on al-Battānī.⁴

Bar Ḥiyya also engaged in messianic speculation in his 'Scroll of the Revealer' (*Megillat ha-megalleh*), depending largely on an interpretation of

³ Abraham Bar Ḥiyya, *La obra Séfer Ḥeshbon mahleket ha-kokabim de R. Abraham Bar Ḥiyya ha-Bargeloni*, ed. J. M. Millás, Barcelona 1959.

⁴ See B. R. Goldstein, 'A New Set of Fourteenth Century Planetary Observations', *Proceedings of the American Philosophical Society* 132 (1988), 371-99, esp. 388, 390, 392. Later in the fourteenth century, Immanuel ben Jacob Bonfils of Tarascon produced a Hebrew version of al-Battānī's tables for epoch 1340: see, e.g., Munich, Staatsbibliothek, MS Heb. 386, fol. 8b-38b, especially fol. 16a, where the heading is: 'table for the mean motion of Saturn according to al-Battānī by R. Immanuel ben Jacob'. Other copies of these tables are found in Munich, Staatsbibliothek, MS Heb. 343, fol. 180b-201b; and in New York, Jewish Theological Seminary of America, MS 2597, fol. 45a-73b.

the Book of Daniel. But in the fifth part of the book he based his messianic speculation on the conjunction Saturn and Jupiter to take place in 1345, about two centuries after his own time. This tradition of astrological eschatology, with its emphasis on the Saturn-Jupiter conjunction of 1345, was later invoked by several Jewish scholars, and then appropriated (and reinterpreted) by scholars in Latin Christendom beginning in the mid-fourteenth century, and continuing for several centuries thereafter. Among its notable proponents was Pierre d'Ailly (d. 1420) who associated the coming of the Antichrist with a Saturn-Jupiter conjunction.⁵ Maimonides scorned such astrological eschatology, but Bar Ḥiyya defended it as consistent with his interpretation of the Book of Daniel. In a letter to Judah ben Barzillai, the rabbinical leader of Barcelona at the time, Bar Ḥiyya argued that the Talmudic rabbis accepted astrology, and that it is justified to use the rules of astrology for all that relates to the world as well as to each individual in it. To get around astrological fatalism, he adds that 'the righteous of Israel—unlike the other nations—can nullify the decrees of the motions of the planets from upon them through their righteous deeds and their prayers'.⁶ One may see in this remark an echo of the Talmudic dictum: 'There is no planet (*mazzal*: or zodiacal sign) [that rules] over Israel'.⁷

Abraham Ibn Ezra (d. 1167) was a prolific scholar who wrote in Hebrew on a variety of subjects, and is perhaps best known for his Biblical commentaries.⁸ Yet he was one of the foremost transmitters of Arabic scientific knowledge to the West for both Jews and Christians. Moreover, he had access to Islamic astronomical treatises that are no longer extant, and this has helped in the reconstruction of early Islamic astronomy. Among such works translated by Ibn Ezra that do not survive in the original Arabic are Ibn al-Muthannā's *Commentary on the Astronomical Tables of al-Khwārizmī* and Māshā'allāh's *Book on Eclipses*. Al-Khwārizmī's treatise (early ninth century) is a very important witness for the early stages of

⁵ J. P. Boudet, 'Simon de Phares et les rapports entre astrologie et prophétie à la fin du moyen âge', *Mélanges de l'École Française de Rome* 102 (1990), 617-48, esp. 638.

⁶ R. C. Kiener, 'The Status of Astrology in the Early Kabbalah from the Sefer Yeşirah to the Zohar', *Proceedings of the Second International Conference on the History of Jewish Mysticism*, Jerusalem 1987, 6:1*-42*, esp. 19*.

⁷ 'Eyn mazzal le-Yisrael': see, e.g., Babylonian Talmud, Shabbat 156a. In Maimonides, *The Guide of the Perplexed*, ii.10, transl. S. Pines, Chicago 1963, 269 f, it is noted that the term *mazzal* in Rabbinic texts can mean 'planet' as well as 'zodiacal sign'. For Maimonides's rejection of astrological history, see his 'Epistle to Yemen', I. Twersky, *A Maimonides Reader*, New York 1972, 452 ff.

⁸ Much of the material here about Ibn Ezra derives from my article, B. R. Goldstein, 'Astronomy and Astrology in the Works of Abraham Ibn Ezra', *Arabic Sciences and Philosophy* 6 (1996), 9-21, where additional references may be found. See also *Rabbi Abraham Ibn Ezra: Studies in the Writings of a Twelfth-Century Jewish Polymath*, eds. I. Twersky and J. M. Harris, Cambridge Mass. 1993.

Islamic astronomy in the late eighth and early ninth centuries. But the problems concerning the history of this treatise are considerable because the original Arabic only survives in a Latin translation by Adelard of Bath (early twelfth century) of an Arabic version made in Spain by Maslama al-Majrīṭī (ca. 1000). Moreover, Ibn al-Muthannā's *Commentary* (tenth century) is lost in the original Arabic and only survives in Hebrew and in Latin. Finally, there are two Hebrew versions of this commentary: the one by Ibn Ezra which is short and incomplete, and another longer one which is anonymous.⁹ Ibn Ezra also wrote a treatise, *De rationibus tabularum*, that is extant only in Latin. But he probably composed it in Hebrew, which would mean that the Latin is simply an anonymous translation. This text includes many paraphrases drawn from Ibn Ezra's translation of Ibn al-Muthannā's treatise and, in the treatment of trigonometry, it is explicitly based on the Indian tradition as reported in Ibn al-Muthannā's commentary.¹⁰

Māshā'allāh's *Book on Eclipses* is an astrological text that includes a discussion of the natures of the zodiacal signs as well as of an astrological theory of world history. We learn from various sources that Māshā'allāh was Jewish, but it is not apparent in any of his surviving works. Ibn Ezra clearly indicates in various treatises that he accepted the astrological theory of world history based on conjunctions of Saturn and Jupiter that played an important role in the works of Māshā'allāh (d. 815), among others. Here we are told:

Māshā'allāh said: I have already said that great things take place on account of a great conjunction of the outer planets. Some of these conjunctions indicate great events, for a conjunction of Jupiter and Saturn is a great conjunction and indicates great events. To recognize the event, note the hour of the conjunction, the ascendant, and (the position of) the planets. Know: if the (planetary) ruler of the horoscopic diagram is benevolent, it is an indication of good and the improvement of times, but if it is malevolent, it is an indication of evil, destruction, drought, famine, and war.¹¹

In a previous passage, Māshā'allāh said that a great conjunction is an indication of the rising of prophets and seers.¹²

⁹ B. R. Goldstein, *Ibn al-Muthannā's Commentary on the Astronomical Tables of al-Khwārizmī*, New Haven 1967; B. R. Goldstein, 'The Hebrew Astronomical Tradition: New Sources', *Isis* 72 (1981), 237-51, esp. 250.

¹⁰ Abraham Ibn Ezra, *El libro de los fundamentos de las Tablas astronómicas de R. Abraham Ibn Ezra*, J. M. Millás, Madrid 1947; J. D. North, *Richard of Wallingford*, 3 vols., Oxford 1976, 2:266. In J. D. North, *Horoscopes and History*, London 1986, 23 ff, there is a detailed analysis of a method for domification that is first described in several works by Ibn Ezra, including *Fundamentos de las Tablas*.

¹¹ B. R. Goldstein, 'The Book on Eclipses of Māshā'allāh', *Physis* 6 (1964), 205-13, esp. 212.

¹² Goldstein, 'The Book on Eclipses', 211.

Since Ibn Ezra was one of the first scholars to write on scientific subjects in Hebrew, he had to invent or adapt many Hebrew terms to represent the technical terminology of Arabic. Some of his coinages were accepted by later Hebrew authors, while many others were not. As an example of a mixed reception, there is the case of Ibn Ezra's introducing the term *maḥberet* for conjunction (of the Sun and the Moon and, more generally for two, or more, celestial bodies). This innovation was accepted by some later writers, but others followed Ibn Gabirol and Abraham Bar Ḥiyya who used for this phenomenon either *deviqah* or *dibbuq* (both of which are derived forms from the same root in Hebrew).¹³

The aid of a Jewish collaborator who knew Arabic in a translation from Arabic into Latin by a Christian is reported on a number of occasions, presumably because some Christian translators had a deficient knowledge of Arabic. One well known example of this procedure is mentioned in the preface to the Latin version of Avicenna's *De anima* (between 1152 and 1156), under the patronage of the archbishop of Toledo. The Jew, looking at the Arabic text, read it aloud, word by word, in the 'vulgar' language (presumably, Castilian), and the Christian translator simultaneously wrote down a Latin version of what he had heard. The name of the Jew is given as Avendauth who has been identified as Abraham Ibn Daud, a noted Jewish philosopher living in Toledo at the time. It seems that Gerard of Cremona (d. 1187), one of the most prolific translators in Spain of scientific texts from Arabic into Latin, proceeded in much the same way, but took advantage of the services of a Mozarab (i.e., a Christian who had adopted Arabic culture) called Galip, rather than of a Jew. This procedure must have been fairly common in Spain, for Abraham Ibn Ezra assumed (without any evidence) that a Jew served as intermediary in a translation from Sanskrit into Arabic in the eighth century.¹⁴

¹³ The best study of medieval Hebrew mathematical and astronomical terminology is G. B. Sarfatti, *Mathematical Terminology in Hebrew Scientific Literature of the Middle Ages* [in Hebrew and English], Jerusalem 1968. See also S. Gandz, *Studies in Hebrew Astronomy and Mathematics*, New York 1970, 127 ff; and J. Klatzkin, *Thesaurus philosophicus linguae hebraicae et veteris et recentioris*, New York 1968.

¹⁴ M.-T. d'Alverny, 'Les traductions à deux interprètes, d'arabe en langue vernaculaire et de langue vernaculaire en latin', *Traduction et traducteurs au Moyen Âge: Actes du colloque international du CNRS*, 26-28 mai 1986, ed. G. Contamine, Paris 1989, 193-206; Goldstein, *Ibn al-Muthannā's Commentary*, 148; D. Pingree, 'The Fragments of the Works of Ya'qūb Ibn Ṭāriq', *Journal of Near Eastern Studies* 27 (1968), 97-125, esp. 101.

The thirteenth and fourteenth centuries

By far the most important impact of Jews on European astronomy came about from the work of astronomers under the patronage of Alfonso X of Castile (reigned: 1252-1284) whose goal seems to have been to provide his astronomers with a working library for their discipline without having to consult other treatises. In particular, the Alfonsine tables were the most widely used astronomical tables in Europe from the fourteenth to the end of the 16th centuries. The instructions for these tables survive in a Castilian version, but the tables themselves are only extant in a Latin adaptation produced by a group of Christian scholars in Paris in the 1320s. The authors of the Castilian version, as indicated in the prologue, were both Jews, Isaac ben Sid and Judah ben Moses. The prologue also indicates that the king served as patron, and that the tables were compiled at his command. The king did so, we are told, because of discrepancies between observations and computations based on the tables of al-Zarqāllu (eleventh century), and decided that the only way to correct them was to make a series of new observations. Some of these observations are reported in *Yesod 'Olam* by Isaac Israeli of Toledo (fl. 1310), with the prefatory remark: 'I examined [the calculations of] three eclipses, which Rabbi Isaac *ha-Hazzan* b. Sid (or Sayyid) prepared and arranged in the city of Toledo at the command of the king don Alfonso, (...) and [I saw them] in his own handwriting'.¹⁵ There were other astronomers involved at the court, both Jewish and Christian, who produced a set of treatises called the *Libros del Saber de Astronomía*, and most of these works involved at least one Jewish scholar.

To convey some idea of the level of collaboration, we are told in *The Book of the Fixed Stars* that the king himself was engaged in the revision of this work. The text was first translated by Judah ben Moses Kohen and Guillén Arremón Daspa in 1256, but was later revised in 1276 by the same Judah, another Jewish scholar, Samuel, and two Italians, with the active participation of the king. Most of these scholars were engaged in translations from Arabic into Castilian, while some produced new texts, the most important of which was the *Alfonsine Tables*. One of the Jewish collaborators, known as Abraham *alfaquim*, i.e., the physician, translated two texts from Arabic directly into Castilian: *The Book on the Configuration of the World* by Ibn al-Haytham (eleventh century), and the *Escala de*

¹⁵ N. Roth, 'Jewish Collaborators in Alfonso's Scientific Work', *Emperor of Culture: Alfonso X the Learned of Castile and His Thirteenth Century Renaissance*, ed. R. I. Burns, Philadelphia 1990, 59-71, esp. 67. See Isaac Israeli, *Yesod 'Olam*, part iv, chap. 7 (*Liber Jesod Olam, seu Fundamentum Mundi*, eds. B. Goldberg, and L. Rosenkranz, 2 vols., Berlin 1846-48, vol. 1, part iv, p. iv); J. D. North, 'The Alfonsine Tables in England', *Prismata*, eds. Y. Maeyama and W. G. Saltzer, Wiesbaden 1977, 269-301, esp. 270.

Mahoma (the original is lost, but it is preserved in Latin and French translations from the Castilian). Moreover, at the request of King Alfonso, this Abraham revised the Castilian version of the *Azafeha* by al-Zarqāllu that had previously been translated by the Christian scholar, Fernando of Toledo. Abraham *alfaquim* has now been identified as Abraham Ben Waqūr, a member of an eminent Jewish family of scholars and courtiers who, along with his brother Isaac, attended Sancho IV, the successor to Alfonso X, at his deathbed. He and his brother were praised for their knowledge of medicine in a poem by Todros ha-Levi (d. ca. 1306). Moreover, Todros credited Abraham with the ability to foretell the future (*maggid 'atidot*), which may be an allusion his skill as an astrologer.¹⁶ Alfonso was also interested in astrology for, even before becoming king, he had acquired an Arabic manuscript of the *Lapidary* and, as we read in the prologue to the Castilian version:

[Alfonso] obtained it in Toledo from a Jew who held it hidden, who neither wished to make use of it himself nor that any other should profit therefrom. And when he had this book in his possession, he caused another Jew, who was his physician, to read it and he was called Jehuda Mosca *el menor* and he was learned in the art of astrology, and knew and understood well both Arabic and Latin. And when through this Jew his physician he understood the value and great profit which was in the book, he commanded him to translate it from Arabic into the Castillian language, so that men might better understand it and how to profit more from it. And one Garcia Pérez his clerk aided in this translation. He was also learned in the art of astrology.¹⁷

John of Lignères was one of the Parisian scholars responsible for the Latin version of the Alfonsine tables, and in a somewhat earlier work, a set of astronomical tables composed in 1322, he singled out three earlier astronomers for praise: al-Battānī, al-Zarqāllu, and Abraham Benthegar. John added that the introduction (or 'canons') to Abraham's astronomical tables had not yet been translated from Hebrew, 'although it seems to me from what I have heard that they are the best of all, with the exception of those of al-Battānī'.¹⁸ The name Abraham Benthegar may be a corruption of Abraham Ben Waqār despite the linguistic problems with that identification, but Abraham Ben Waqār is not known to have composed any astronomical

¹⁶ D. Yellin, *Gan hammeshalim we-haḥidoth: Diwan of Don son of Yehuda abu-el-ʿAfiah*, Jerusalem 1934, 84. Abraham alfaquim was identified as Abraham ben Waqār by E. S. Procter, 'The Scientific Works of the Court of Alfonso X of Castille', *Modern Language Review* 40 (1945), 12-29, esp. 23.

¹⁷ Procter, 'Alfonso X of Castille', 19. See also D. Romano, 'Le opere scientifiche di Alfonso X e l'intervento degli ebrei', *Oriente e occidente nel medioevo: filosofia e scienza, Atti dei Convegni* 13 (1971), 677-710.

¹⁸ M.-M. Saby, 'Les canons de Jean de Lignères sur les tables astronomiques de 1321', unpublished thesis: Ecole Nationale des Chartes, Paris 1987. A summary appeared in *Ecole Nationale des Chartes: Positions des thèses*, 1987, 183-90.

works in Hebrew. Nevertheless, the fact that John of Lignères, one of the main collaborators in the Parisian Latin version of the Alfonsine tables, praised a Hebrew text that he had not read, is surely evidence of the high esteem of Jewish astronomers at the time. Al-Battānī was a famous astronomer whose astronomical tables had a great influence in Spain, and al-Zarqāllū was the most prominent Spanish-Muslim astronomer whose influence was felt in subsequent generations. Thus, Abraham Benthagar is placed in very good company.

Later Jewish astronomers knew the Alfonsine tables through the Latin version produced in Paris, and that version was translated into Hebrew by Moses ben Abraham de Nîmes in Avignon in 1460. Of interest is that Moses was aware that some of the tables were added after the Alfonsine tables were originally compiled: 'The translator said: this table together with the eight tables that follow do not belong to Alfonso, but they were added to fulfill a need and to be useful', and 'The translator said: here end the tables of King Alfonso with all the supplementary tables that the Christians added to make them complete so that the astronomer will not need any other tables'. Several of these supplementary tables appear in the *editio princeps* of the Latin version (published by Ratdolt in 1483), but they are not designated as supplementary there.¹⁹ So readers of Moses's Hebrew version had access to information, ultimately derived from the Latin manuscripts, that was not generally available to readers of the *editio princeps*. Recently, an anonymous Hebrew version of the Alfonsine tables has been found—it seems to derive from late fifteenth century Spain, and one of the epochs in it is 1473.²⁰

Jewish scholars served at several royal courts, but none had the impact of the astronomers who served Alfonso X. For example, Jacob b. Abba Mari Anatoli was a physician and philosopher who, in the 1230s, served Emperor Frederick II at his court in Naples, where he assisted in translations from Arabic into Latin by Michael Scot that played a role in a political dispute with the pope.²¹ Jacob translated a number of Arabic treatises into Hebrew,

¹⁹ B. R. Goldstein, 'Solar and Lunar Velocities in the Alfonsine Tables', *Historia Mathematica* 7 (1980), 134-40, esp. 137 f; *Alfontii regis castellae illustrissimi Caelestium motuum tabulae*, Venice 1483; E. Poulle, *Les tables alphonsines avec les canons de Jean de Saxe*, Paris 1984. See also North 'Alfonsine Tables in England', and J. D. North, 'Just whose were the Alfonsine Tables?' *From Baghdad to Barcelona: Studies in the Islamic Exact Science in Honour of Prof. Juan Vernet*, eds. J. Casulleras and J. Samsó, 2 vols., Barcelona 1996, 1: 453-75.

²⁰ St. Petersburg, Rossiiskaia akademiia nauk, MS Heb. C-076, fol. 31a-54a. Another version of the Alfonsine tables in Hebrew is preserved in Milan, Ambrosiana, MS Heb. X-193 Sup. The handwriting in this Hebrew manuscript is Italian, and it probably dates from the late fifteenth century.

²¹ Cf. G. Freudenthal, 'Maimonides's *Guide of the Perplexed* and the Transmission of the Mathematical Tract "On Two Asymptote Lines" in the Arabic, Latin and Hebrew Traditions', *Vivarium* 26 (1988), 113-40, esp. 122, 128; G. Freudenthal, 'Les sciences dans les

including Averroes's *Epitome of the Almagest* (of which the original Arabic is lost) and Ptolemy's *Almagest*. Jacob also reports on conversations with the Emperor and with Michael Scot on scientific and philosophical issues. For example, concerning a passage in Maimonides's *Guide of the Perplexed*, ii.26, related to Job 37:6, Jacob tells us that 'our master, the Emperor Frederick, explained the reason why the term "snow" was used to designate prime matter (...)'.²²

The conditions of Jewish life in Spain deteriorated in the course of the fourteenth century, and a series of riots, beginning in Seville in 1391, resulted in the conversion of a significant number of Jews. The period of instability lasted for a long time, and many Jews fled to other countries. One such refugee was probably Isaac al-Hadib, the Spaniard, who was active in Sicily in 1396 but, as far as I know, al-Hadib does not say why he left Spain. In his astronomical tables written in Hebrew, he mentions Muslim and Jewish predecessors, and a Hebrew commentary on these tables was written in the 16th century in Egypt by Abraham Gascon.²³ He also composed a text describing an equatorium, which he called 'The Precious Instrument' (*Keli hemda*), whose purpose was to replace the use of tables for calculating planetary positions by an instrument that only requires the turning of dials. The tradition of making such instruments began in the Islamic world some centuries earlier, and the variety of ways to construct such equatoria, all of which represented the Ptolemaic planetary models, is quite astonishing. Al-Hadib begins his treatise as follows:

To find the true positions of the seven planets [the five planets plus the Sun and the Moon] (...) involves difficulty and effort in the (use of) all the different kinds of tables that have been composed for these purposes that cannot be avoided. (...) Moreover, errors affect the results (...) because of the multitude of operations, sometimes to be added and sometimes to be subtracted. The person computing the (planetary) position may add when he was supposed to subtract, and vice versa. (...) Many tried to construct instruments to simplify this as was done for the Sun [on the back of] the astrolabe (...) But these instruments came with lengthy instructions and could only be used with great difficulty. (Such is the case) with the instrument ascribed to al-Zarqallu and others (ascribed) to Christian scholars. (...) In the year 5156 [= 1396 A.D.] in Syracuse on the island of Sicily (...) I invented an instrument that is easy to construct and it is accurate to a degree [of longitude]. The astrologers rely on

communautés juives médiévales de Provence: leur appropriation, leur rôle', *Revue des études juives* 152 (1993), 29-136, esp. 50.

²² C. Sirat, 'Les traducteurs juifs à la cour des rois de Sicile et de Naples', *Traduction et traducteurs au Moyen Age: Actes du colloque international du CNRS, 26-28 mai 1986*, ed. G. Contamine, Paris 1989, 169-91, esp. 172.

²³ Goldstein, 'The Hebrew Astronomical Tradition', 240.

the astrolabe (...) and there is no doubt that the approximation with the astrolabe is far greater than that found in this instrument.²⁴

Al-Ḥadib then goes on to explain the construction and use of his instrument. After an extensive search of Hebrew manuscripts, I found only five such instruments described in Hebrew, and there does not seem to be any surviving example. Two of them are ascribed to a certain Joseph ha-Parsi who is otherwise unknown. The first is called 'The golden instrument' (*Keli paz*), composed in Seville in 1439, and the second is called 'The instrument of exile' (*Keli golah*), composed by the same author in 1444 in Bologna, Italy. So it seems that this is also a case of a Spanish refugee. From another such text it is clear that the 'market' for equatoria was probably driven by practitioners of astrological medicine who needed to find planetary positions in order to cast horoscopes, but whose mathematical skills may have been limited.²⁵

The fifteenth century

The two outstanding Jewish astronomers in the Iberian peninsula during the fifteenth century were Judah ben Verga, and Abraham Zacut. Ben Verga was active in the 1450s and 60s and is associated with Lisbon (Portugal) where he made some astronomical observations. He also composed astronomical tables that have recently been identified by Tzvi Langermann.²⁶ Abraham Zacut was born in Salamanca (Spain), probably in 1452, and left Spain at the time of the expulsion in 1492. He wrote a lengthy astronomical treatise with both an introduction and tables, entitled: *The Great Composition (ha-Ḥibbur ha-gadol)*, and the epoch of the tables is the year 1473. Zacut finished his work around 1478, and three years later the treatise was translated from Hebrew into Castilian, with the help of Zacut himself, by Juan de Salaya, who had previously held the chair of astronomy at the University of Salamanca. The tables were printed in Latin in Leiria (Portugal) in 1496,

²⁴ B. R. Goldstein, 'Descriptions of Astronomical Instruments in Hebrew', *Essays in Honor of E. S. Kennedy*, eds. D. A. King and G. Saliba, *Annals of the New York Academy of Sciences* 500 (1987), 105-41, esp. 128.

²⁵ P. Barker and B. R. Goldstein, 'The Role of Comets in the Copernican Revolution', *Studies in the History and Philosophy of Science* 19 (1988), 299-319, esp. 311 n 24; Goldstein 'Descriptions of Astronomical Instruments', 119 f; B. R. Goldstein, 'Scientific Traditions in Late Medieval Jewish Communities', *Les Juifs au regard de l'histoire: Mélanges en l'honneur de M. Bernhard Blumenkranz*, ed. G. Dahan, Paris 1985, 235-47, esp. 239.

²⁶ The canons of Ben Verga's tables are preserved in St. Petersburg, Rossiiskaia akademiia nauk, MS Heb. C-076, fol. 57a-65a; and the tables in Paris, Bibliothèque Nationale, MS Heb. 1085, fol. 86b-98a, and Oxford, Bodleian Library, MS Heb. Nb. 2044, fol. 222b-236b. For other works by Ben Verga, see M. Steinschneider, *Mathematik bei den Juden*, 2nd edn., Hildesheim 1964, 196.

with an introduction in Latin in some copies and in Castilian in others. The colophon at the end of this printed text tells us that Joseph Vizinus was the translator (and d'Ortas the printer), but the introduction, with instructions for using the tables, in Latin (or Castilian) is sufficiently different from the corresponding Hebrew text to be considered a distinct work.²⁷

It has been suggested that Zacut was a professor at the University of Salamanca, but this is clearly contradicted by the list of professors of astronomy in his lifetime. Alternatively, it has been suggested that he was a student at the University of Salamanca. Both claims are based on the same passage in the preface to the Latin version published in 1496 (but not in the Castilian variant) for which there is no Hebrew counterpart. According to this preface, the text is dedicated to an unnamed 'presbyter' of Salamanca, usually taken to be the bishop of Salamanca who died in 1480 and is supposed to have been Zacut's patron. But this preface was taken, almost word-for-word, from a dedication to a bishop in Hungary by Regiomontanus in his *Tabulae directionem* that was published in 1490, and the insertion of that dedication into the Latin version of Zacut's tables was most probably due to Vizinus, 'the translator', or possibly to d'Ortas, the printer.²⁸ Zacut's Hebrew text does not allude to this bishop at all, and Juan de Salaya's translation in 1481 does not do so either. Moreover, the introduction to Zacut's tables in Hebrew is clearly addressed to a Jewish audience, rather than to a Christian patron.²⁹ In short, there is no longer any credible evidence for a formal association of Zacut with the University of Salamanca.

The tables themselves are quite extensive, and Zacut based them primarily on the Alfonsine tables, the tables of Jacob Poël, and the tables of Judah ben Asher (d. 1391), the great grandson of the famous Rabbi of Toledo, Asher ben Yeḥiel (d. ca. 1328). The tables of Judah ben Asher have

²⁷ Zacut, *Tabulae tabularum celestium motuum astronomici zacuti*, Leiria 1496; for the Hebrew canons: Oxford, Bodleian Library, MS Opp. 8° 42; and for the Hebrew canons and tables: Lyon, Bibliothèque Municipale, MS Heb. 14; Munich, Staatsbibliothek, MS Heb. 109; and Warsaw, Żydowski Instytut Historyczny, MS Heb. 245. The most important studies of Zacut's astronomical works are F. Cantera Burgos, 'El judío salmantino Abraham Zacut', *Revista de la Academia de Ciencias de Madrid* 27 (1931), 63-398; and F. Cantera Burgos, *Abraham Zacut*, Madrid 1935. See also B. R. Goldstein, 'Abraham Zacut and the Medieval Hebrew Astronomical Tradition', *Journal for the History of Astronomy* 29 (1998), 177-86.

²⁸ Regiomontanus, *Tabulae directionum*, Augsburg 1490, fol. a2'-a3'; Zacut, *Tabulae tabularum celestium motuum*, fol. 2'-2^v. This similarity was first noted in B. Cohn's review of *Almanach perpetuum coelestium motuum (radix 1473)* (...) *Reproduction facsimilé*, Edition 1496, (...) München 1915', in *Vierteljahrsschrift der Astronomischen Gesellschaft* 25 (1917), 102-23, esp. 106; and later in E. Zinner, *Regiomontanus: his life and work*, transl. E. Brown, Amsterdam 1990, 121, but was not mentioned in Cantera, *Abraham Zacut* (see esp. 21 ff).

²⁹ For the Hebrew text of the introduction with German translation, see B. Cohn, *Der Almanach perpetuum des Abraham Zacuto*, Schriften der wissenschaftlichen Gesellschaft in Strassburg, 32. Heft, Strassburg 1918; for a Spanish translation, see Cantera 'El judío salmantino Abraham Zacut', 239 ff.

recently been identified by Tzvi Langermann in a Vatican Hebrew manuscript, and they are of considerable interest in their own right.³⁰ One set of tables in Zacut's *magnum opus* may serve as an example of the extent and quality of his achievement. There is a table, described in chapter 3 of the Hebrew text and in chapter 4 of the printed Latin edition, for the daily true positions of the Moon at noon in Salamanca for each day in a cycle of 31 years beginning on March 1, 1473; this table has 11,325 entries given to minutes of arc. The cycle of 31 years is one that was discovered by Jacob Poël and used in his tables for true conjunctions and oppositions of the Sun and the Moon computed for Perpignan for a period of 31 years, beginning in 1361; Jacob Poël had fewer than 750 lunar positions to compute.³¹ In his introduction Zacut credits Jacob Poël for this cycle, but the entries in Zacut's table were computed with the Alfonsine tables and, with them, a recomputation of all the entries for March 1473 shows no discrepancy greater than a minute of arc.³² The only other table preserved in a Hebrew text comparable to Zacut's lunar table, with 11,325 entries, is found in the Vatican Hebrew manuscript that has the tables of Judah ben Asher.³³ I am not aware of such extensive tables of daily lunar positions in either Arabic or Latin.

Zacut's arrival in Portugal in 1492 did not go unnoticed by the royal court at the time when astronomical principles were being introduced into navigation, though historians may have exaggerated his role.³⁴ But the

³⁰ Y. T. Langermann, 'Sefer *Huqqot Shamayim* by R. Judah ben Asher', *Kiryat Sefer* 58 (1983), 622-23 [in Hebrew]. The canons begin, 'And this belongs to Judah (...)': Vatican, Bibliotheca Apostolica, MS Heb. 384, fol. 284a. From the rest of the canons, and Zacut's references to them, it is clear that this Judah is Judah ben Asher who died in 1391, and not the son of Asher ben Yehiel who bore the same name and died in 1349. On the various members of this family, see A. Freimann, 'Die Ascheriden (1267-1391)', *Jahrbuch der Jüdisch-Literarischen Gesellschaft* 13 (1920), 142-254.

³¹ On Jacob Poël (Jacob Bonjorn), see J. Chabás, 'The astronomical tables of Jacob ben David Bonjorn', *Archive for History of Exact Sciences* 42 (1991), 279-314; and J. Chabás, *L'astronomie de Jacob ben David Bonjorn*, Barcelona 1992. New evidence for the occurrence of this 31-year cycle in Arabic has just come to light: see J. Samsó, 'Andalusian Astronomy in 14th Century Fez: al-Zij al-Muwāfiq of Ibn 'Azzūz al-Qusantīni', *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* 11 (1997), 73-110, esp. 86 ff.

³² See J. Chabás and B. R. Goldstein 'Abraham Zacut and Iberian Astronomy in the Late fifteenth Century' [in preparation].

³³ Vatican, Bibliotheca Apostolica, MS Heb. 384, fol. 347a-359a. Unfortunately, there are no dates in this table which makes it rather difficult to recompute its entries.

³⁴ Cantera, *Abraham Zacut*, 33 ff. The only early Portuguese historian who mentions Zacut's role in navigation is Gaspar Correa (d. 1583?), and it is difficult to assess his reliability since he was not a direct witness to the events when Zacut was in Portugal: see J. Bensaude, *Histoire de la science nautique portugaise: résumé*, Geneva 1917, 74-78. Correa wrote his *Lendas da India* in Goa, India, between 1529 and 1561 and claims that he gathered his information from the sailors of Vasco da Gama: J. Bensaude, *L'astronomie nautique au Portugal*, Berne 1912, reprint ed. Amsterdam 1967, 133.

conditions of the Jews in Portugal quickly deteriorated, and Zacut had to emigrate to North Africa after only a few years in Portugal. Zacut composed a new set of astronomical tables when he was in North Africa and another when he reached Jerusalem. The latter tables were arranged for the Jewish calendar in contrast to his earlier tables that were arranged for the Christian calendar. In an unpublished manuscript we learn that at the age of 61, in 1513, Zacut resided in Jerusalem at the academy of Isaac Sholal, the leader (*nagid*) of the Jewish communities in Egypt and Palestine, who brought many Spanish refugee scholars to his academy. Zacut's fame is reflected in subsequent Hebrew astronomical texts such as those by Ḥayyim Vital (d. 1620), the great disciple of the mystic Isaac Luria, and Jacob Mizrahi (Aleppo, ca. 1685).³⁵

Zacut was also interested in messianic speculation, and composed a treatise in 1498 (while in North Africa) in which astrological interpretations of eclipses and planetary conjunctions were prominent. According to his theory, messianic fulfillment would begin in 5264 A.M. (= 1503/4).³⁶

Conclusion

We should not be surprised that astronomical observations played only a minor role in the works of medieval Jewish astronomers, despite the great ingenuity and enormous effort displayed in them. The Alfonsine tables might seem to be an exception since we are told that the observations of eclipses motivated the renovation of previous tables. But, in fact, the eclipse tables in the Alfonsine tables were taken over without any modification from a previous set, known as the Toledan tables. It would then seem that the appeal to observations may have been a pretext to get royal support for the enterprise—there are similar cases in the Islamic world.³⁷ The emphasis in recent literature on observational activity is largely due to modern notions of what a scientist should do; there was no such requirement in the Middle Ages.³⁸ It was not easy to master the astronomical literature and to contribute

³⁵ Goldstein, 'The Hebrew Astronomical Tradition'. Zacut's tables for 1501 and 1513 are only extant in fragments.

³⁶ M. Beit-Arié and M. Idel, 'Treatise on Eschatology and Astrology by R. Abraham Zacut', *Kiryat Sefer* 54 (1979), 174-94 [in Hebrew].

³⁷ A. Sayili, *The Observatory in Islam*, Ankara 1960, 204.

³⁸ Even when a medieval astronomer made observations, they were rarely used to modify a theory. This is the case for the eclipse observations made by Alfonso's astronomers, cited above, and those made in the fourteenth century by John of Murs: see G. Beaujouan, 'Observations et calculs astronomiques de Jean de Murs (1321-1344)', *Proceedings of the XIVth International Congress of the History of Science (Tokyo and Kyoto 1974)*, Tokyo 1975, 2:27-30 (reprinted as Essay VII in G. Beaujouan, *Par raison de nombres: L'art du calcul et les savoirs scientifiques médiévaux*, Aldershot, Hampshire, 1991). More typical is the tradition of

to it, and those who did so were generally admired. Zacut's astronomical work is, in this regard, typical, for he hardly recorded any observations in it.³⁹ Instead, he devoted considerable ingenuity to making his tables easier to use than those previously available. Similarly, al-Ḥadib was motivated to invent his equatorium in an effort to simplify calculations. Most medieval astronomers shared this perspective on their art although Levi ben Gerson is a major exception to this rule.⁴⁰ Moreover, astronomy was valued because it raised the prestige of Jews in the eyes of their Gentile neighbors. Indeed, the study of astronomy was not included in the ban on philosophy enacted in Barcelona in 1305.⁴¹

Throughout the Middle Ages the Spanish community was the model for Jewish interest in science, and its impact was felt in all parts of the Jewish world. In most cases, we can find the agent, usually a refugee from Spain, who brought scientific texts to communities that previously had little or no scientific tradition. This was true for southern France with the arrival in the twelfth century of the Tibbonids and others,⁴² it was true for Sicily at the end of the fourteenth century with the arrival of al-Ḥadib, and it was true for Jerusalem in the 16th century with the arrival of Abraham Zacut. No other Jewish community was able to take on this role after the expulsion in 1492, and Jews did not participate to any great extent in the astronomical revolution from Copernicus to Newton.

the star list compiled by Ibn al-Kammād (early twelfth century, Spain) which was integrated without any changes into a variety of subsequent texts in Arabic, Hebrew, and Latin: see B. R. Goldstein and J. Chabás, 'Ibn al-Kammād's Star List', *Centaurus* 38 (1996), 317-34; and Samsó, 'Andalusian Astronomy in 14th Century Fez', 107-10.

³⁹ Cantera, 'El judío salmantino Abraham Zacut', 300. Zacut observed an occultation of Spica by the Moon in 1474, but does not specify the date. Modern computation indicates that such an occultation occurred a little after 22h00 UT, 26 May 1474. [I am grateful to Dr. David Dunham for computing the conditions of this occultation]. A second observation, reported in only one extant manuscript, has recently come to light: see B. R. Goldstein and J. Chabás, 'An Occultation of Venus Observed by Abraham Zacut in 1476', in *Journal for the History of Astronomy* [in press].

⁴⁰ See B. R. Goldstein, 'The Physical Astronomy of Levi ben Gerson', *Perspectives on Science* 5 (1997), 1-30, and references in it. Levi made a large number of observations (by medieval standards), and used them to construct and modify theories. For a preliminary discussion of the theoretical and observational interests of al-Maghribī (d. 1283), one of the astronomers at the observatory at Maragha, see G. Saliba, *A History of Arabic Astronomy*, New York 1994, esp. 166 ff.

⁴¹ Y. Baer, *A History of the Jews in Christian Spain*, 2 vols., Philadelphia 1966, 1:301 ff.

⁴² Freudenthal 'Les sciences dans les communautés juives médiévales de Provence', 43 ff.

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EDWARD GRANT

GOD, SCIENCE, AND NATURAL PHILOSOPHY
IN THE LATE MIDDLE AGES

Andrew Cunningham and Roger French have made important and provocative claims about natural philosophy and science to which I should like to reply.¹ The major claim asserts that the object of natural philosophy as a discipline was the study of God's creation and God's attributes. So powerful was this objective, that Cunningham proclaims 'that natural philosophy was not just 'about God' and His creation at those moments when natural philosophers were explicitly talking or writing about God in their natural philosophical works or activities. It was, by contrast, 'about God' and His creation the whole time.'²

Cunningham acknowledges that he has here taken 'something of a blank cheque (...) to make any claim I like without having to produce any evidence'.³ It is indeed a 'blank cheque'. We cannot know what was in the minds of medieval or early modern natural philosophers as they wrote their treatises. In view of the celibate status of medieval natural philosophers, their thoughts, as they wrote their treatises, may just as plausibly have been filled with sexual fantasies, along with, or in lieu of, God and His creation. Or, perhaps, they simply filled their minds with the problems of natural philosophy. It is best to leave such matters to psychohistorians. In this article, I shall evaluate only the extant writings of medieval natural philosophers. When they write about God and faith, then that segment of their writings is about God and the faith. But when there is no mention of God and faith, or allusions to them, then it is not about God and faith.

Because they are convinced that medieval natural philosophy was primarily about God and the creation, French and Cunningham conclude that what has been interpreted as science is really natural philosophy, from which it follows that nothing we could properly call 'medieval science' existed that is in any way comparable to modern science. Indeed, the very title of their book, *Before Science*, makes this first claim quite apparent.⁴ The claim is

¹ See A. Cunningham, 'How the *Principia* Got Its Name; Or, Taking Natural Philosophy Seriously', *History of Science* 29 (1991), 377-392; and also R. French and A. Cunningham, *Before Science: The Invention of the Friar's Natural Philosophy*, Aldershot 1996.

² Cunningham, 'How the *Principia* Got its Name', 388.

³ Cunningham, 'How the *Principia* Got its Name', 382.

⁴ *Before Science*, 273, where they declare that 'there was no scientific tradition (in the modern sense of the term "scientific") of looking at nature in the thirteenth century, only a religio-political way of doing so. Natural philosophy was not the same as modern science'.

based on the assumption that, unlike natural philosophy, 'modern science does *not* deal with God or with the universe as God's creation', an assumption that 'is one of the most basic things that the members of the modern scientific community hold in common'.⁵ In what follows, my main concern will be to argue that natural philosophy is *not* primarily about God and His creation. Before turning to that, however, I want to deny the claim that there was no science in the Middle Ages, and also to reject the sharp dichotomy that Cunningham and French draw between medieval natural philosophers, who allegedly always thought about God and His creation in all their works, and modern scientists, who supposedly eliminated God and His creation from their works.

To show this, I offer a comparison of two treatises, *The Book of Jordanus de Nemore On the Theory of Weight* (*Jordani de Nemore Liber de ratione ponderis*),⁶ a thirteenth century treatise by Jordanus of Nemore, and 'On the Electrodynamics of Moving Bodies', an article composed by Albert Einstein in 1905.⁷ Inspection of both works shows at a glance that they are highly mathematical and spare in their exposition (Jordanus's, ironically, being more spare than Einstein's). Jordanus uses geometry, and Einstein the calculus, but that is irrelevant. Both treatises would meet reasonable and appropriate criteria for being scientific. In the Middle Ages, Jordanus's treatise would have been regarded as a 'middle science', that is, a science that is neither natural philosophy nor pure mathematics, but one that lies between them because it involves the application of mathematics to natural philosophy.⁸ Jordanus's work also possesses the other attributes of a modern scientific treatise: it makes no mention of God or His creation, and indeed has nothing in it about the faith or the supernatural. And yet we may plausibly assume that Jordanus, like Einstein, believed in a supreme being. It is evident, however, that the religious beliefs of Jordanus and Einstein, exercised *no detectable influence* on their respective treatises, which are wholly devoid of religious or theological content or sentiment. Einstein's article is 'modern science' by definition. Jordanus's treatise cannot be 'modern science' by definition. It is 'medieval science', just as Ptolemy's

⁵ Cunningham, 'How the *Principia* Got its Name', 382-383.

⁶ For the Latin text and English translation, see *The Medieval Science of Weights* ('*Scientia de ponderibus*'), *Treatises ascribed to Euclid, Archimedes, Thabit ibn Qurra, Jordanus de Nemore and Blasius of Parma*, eds. and transl. E. A. Moody and M. Clagett, Madison 1952, 174-227. E. Moody edited and translated Jordanus's *On the Theory of Weight*.

⁷ A. Einstein, 'On the Electrodynamics of Moving Bodies', translated from 'Zur Elektrodynamik bewegter Körper', *Annalen der Physik* 17, 1905, in H. A. Lorentz, A. Einstein, H. Minkowski and H. Weyl, *The Principle of Relativity: A Collection of Original Memoirs on the Special and General Theory of Relativity*, with notes by A. Sommerfeld; transl. W. Perrett and G. B. Jeffrey, New York 1952 [first published 1923], 37-65.

⁸ The basis for distinguishing middle sciences lies in Aristotle's *Posterior Analytics*, chs. 13 and 14. For discussions of the relationships between natural philosophy, mathematics, and middle sciences, see the entries in the bibliography under Livesey, 22-29; Laird, ch. 2; Sylla, 355; and Day, 137 and n. 51, 164-165.

Almagest is 'ancient science'. But the treatises of Jordanus de Nemore and Ptolemy deserve the title 'science' just as much as Einstein's article on electrodynamics. One can multiply similar examples.⁹

Finally, Cunningham's claim that 'modern science does not deal with God or with the universe as God's creation', and that this assumption 'is one of the most basic things that the members of the modern scientific community hold in common', is quite misleading. The fact that modern scientists do not mention God or His creation in their publications and in their professional lives does not mean that God and His creation may not play a significant role in their lives and influence their thoughts about the universe. In a recent survey of 1,000 scientists (one-half were biologists; one-quarter mathematicians; and one-quarter physicists and astronomers) whose names were drawn at random from *American Men and Women of Science* (1995), 600 responded to a series of queries about their religious beliefs.¹⁰ The questions posed to the scientists were exactly the same as those put to 1,000 scientists by James Leuba in 1916, with virtually the same results: 'about 40 percent of scientists still believe in a personal God and an afterlife'.¹¹ Although he never participated in any of these surveys and may not have believed in an afterlife, Albert Einstein, who claimed that religious beliefs motivated his scientific research, clearly belongs among those scientists who admit to belief in a supreme being. Einstein insisted 'that the cosmic religious feeling is the strongest and noblest motive for scientific research'¹² and was convinced that religious feeling for the scientist 'takes the form of a rapturous amazement at the harmony of natural law, which reveals an intelligence of such superiority that, compared with it, all the systematic thinking and acting of human beings is utterly insignificant. This feeling is the guiding principle of his life and work, in so far as he succeeds in keeping himself from the shackles of selfish desire. It is beyond question closely akin to that which has possessed the religious geniuses of all ages'.¹³

⁹ For example, the *Perspectiva communis* of John Pecham (ca. 1230-1292), a Franciscan theologian, who wrote the treatise around 1277-1279. Pecham's work includes nothing whatever about God, theology, the faith or anything supernatural, which stands in contrast to his earlier *Tractatus de perspectiva*. For a comparison of the two treatises, see *John Pecham Tractatus de perspectiva*, ed. D. C. Lindberg, St. Bonaventure N.Y. 1972, 13.

¹⁰ E. J. Larson and L. Witham, 'Scientists are Still Keeping the Faith', *Nature* 386 (3 April 1997), 435-436. 'Our survey', the authors explain, 'polled only about 3 percent of the biological and physical scientists and mathematicians listed in the 1995 American Men and Women of Science'. For a summary of the report, see the New York Times of April 3, 1997.

¹¹ *Ibid.*, 435. The authors of the survey report (p. 436) that their 'findings do corroborate a large survey done in 1969 by the Carnegie Commission, asking 60,000 professors in the United States questions such as "how religious do you consider yourself?". The commission found that 34 percent of physical scientists were "religiously conservative" and about 43 percent of all physical and life scientists attended church two or three times a month—on a par with the general population'.

¹² Albert Einstein, *Ideas and Opinions. Based on 'Mein Weltbild'*, ed. C. Seelig, and other sources; new translations and revisions by S. Bargmann, 3rd ed., New York 1954; 1982, 39.

¹³ Einstein, *Ideas and Opinions*, 40.

Despite these sentiments, Einstein was not moved to mention God in his scientific treatises. On Cunningham's approach, we may infer from the absence of God and the creation from Einstein's published works that God played no role in his thinking. But we saw that would be patently false. It is equally objectionable to infer that medieval natural philosophers and theologians are thinking about God and the creation even when they do not mention God or the creation. We would be well advised to make no inferences about the role of God in a treatise where God and the creation are not mentioned, whether that treatise was composed by medieval natural philosophers or modern scientists. In what follows, I shall rightly assume that all medieval natural philosophers and theologians believed on faith that God created the world and was the ultimate cause of all effects. From this assumption, however, I shall not infer, in the absence of explicit citations and discussion, that an author had God and the creation in mind while writing on this or that topic. Without some evidence, we may not argue from silence.

God and natural philosophy

When investigating connections between God and natural philosophy in the Middle Ages, it is essential to distinguish two quite different aspects of this relationship: (1) the intrusion of God, His creation and theology into the commentaries and questions on Aristotle's natural books, and therefore into natural philosophy; and (2) the intrusion of natural philosophy into theology, that is, the importation of natural philosophy into theological treatises by theologians (especially in *Commentaries on the Sentences of Peter Lombard*), where natural philosophy was treated in traditional terms as a 'handmaiden to theology', or to combat heretical opinions.¹⁴ Natural philosophers readily admitted that God had created our world—indeed, they could hardly have done otherwise—and governed it. But they never regarded it as their primary aim to focus on God and His supernatural creation. That was a task better left to professional theologians in their theological treatises. The objective of natural philosophers was to explicate the workings of the physical world within the framework of Aristotle's natural books and to do so in the manner exemplified by Aristotle and his great Islamic commentator, Averroes, that is, to do so by natural reason and not by invocation of the supernatural. Natural philosophy was an independent discipline taught in the medieval universities to all who were interested, but

¹⁴ The authors of *Before Science* base their arguments for a natural philosophy that is about God and His creation largely on the second way. By design, their study ignores the massive body of commentary literature on Aristotle's natural books (see Epilogue, 269-272; for the literature on natural philosophy, see below, note 16), which represents natural philosophy done for its own sake rather than as an aid to understanding theology.

especially to those who wished to pursue a career as teachers of natural philosophy, a relatively small group; or to a far larger group who required it as a prerequisite for matriculation toward a higher degree in law, medicine, or theology. Theologians were expected, if not required, to attain a masters' degree in natural philosophy. As a consequence, they were quite familiar with natural philosophy, sufficiently familiar so that we may appropriately describe them as 'theologian-natural philosophers'.

Those who commented on the natural books of Aristotle were usually teaching masters in an arts faculty, although some would eventually matriculate in a theology faculty and become professional theologians. When they wrote their Aristotelian commentaries, they had every incentive to keep their natural philosophy natural. Under pressure from theologians and the theological faculty of the University of Paris, who were alarmed at the manner in which some arts masters taught natural philosophy, the arts faculty itself, in 1272, instituted an oath that made it mandatory for arts masters to avoid theological discussions in their questions. Where this was unavoidable, they were sworn to resolve the issue in favor of the faith.¹⁵

In the course of teaching and studying Aristotle's natural books in the arts faculties of medieval universities for more than three centuries, a vast body of commentary literature was produced.¹⁶ Those who wrote these treatises firmly believed that God had created the world from nothing, and that He was the ultimate cause of all events or effects, the First Cause (*prima causa*), as He was frequently called. How did these Christian beliefs affect the way medieval scholars wrote natural philosophy? Did it mean that their objective in doing natural philosophy was essentially theological or religious? That their aim was to transform natural philosophy into an instrument for the defense of the faith and therefore to intrude as much religious material as possible into their investigations into natural questions?

The most effective way to respond to these questions and judge the impact of God and religion on this body of natural philosophy is to examine the extant texts of natural philosophers. We must determine what they actually said and did. Our judgments and interpretations must be based on the texts of natural philosophy as written by those who were consciously doing natural philosophy, not theology. That is, we must carefully inspect treatises on natural philosophy *per se*, not treatises on theology that used natural philosophy in the service of theology. As we shall see, a remarkable feature of medieval natural philosophy is that most theologians, who did not

¹⁵ For the relevant document, see L. Thorndike, *University Records and Life in the Middle Ages*, New York 1944, 85-86.

¹⁶ To obtain a good sense of the extant number and range of these commentaries from 1200 to 1650, see C. H. Lohr, 'Medieval Latin Aristotle Commentaries', in *Traditio*, 23 (1967), 33-413; 24 (1968), 149-245; 26 (1970), 135-216; 27 (1971), 251-351; 28 (1972), 281-396; 29 (1973), 93-197; 'Supplementary Authors', 30 (1974), 119-144; and Lohr, *Latin Aristotle Commentaries, II: Renaissance Authors*, Florence 1988.

hesitate to import natural philosophy into their theological works to resolve Scriptural dilemmas and problems of the faith, refrained from needlessly introducing God and the supernatural when they themselves wrote treatises on natural philosophy, that is, when they wrote questions and commentaries on the natural books of Aristotle. Albertus Magnus and Thomas Aquinas are prime examples of this tendency.

The core of medieval natural philosophy lay in the five major treatises of Aristotle's natural books, namely *Physics*, *On the Heavens* (*De caelo*), *On Generation and Corruption* (*De generatione et corruptione*), *On the Soul* (*De anima*), and the *Meteorology*. Although comments about God and the faith might be inserted almost anywhere if an author chose to do so, occasions for so doing were almost unavoidable in parts of the *Physics*, *On the Heavens*, and *On the Soul*. To assess the role of God and the faith in natural philosophy, it is essential to examine commentaries and questions on all five books, but especially the three just cited, that were composed during the thirteenth and fourteenth centuries.

Scholastic attitudes toward natural philosophy

For this study, I have examined a number of commentaries and questions on Aristotle's natural books. Included are commentaries by Albertus Magnus, and Thomas Aquinas in the thirteenth century, and by John Buridan, Nicole Oresme, Themon Judaeus, and Albert of Saxony in the fourteenth century. The most important point about medieval natural philosophy that emerges from these commentaries and questions on Aristotle's natural books is that natural philosophy was about Aristotle's principles, ideas, and concepts, and was therefore about natural phenomena and not about God, faith, and the supernatural. Although it was inevitable within the context of medieval Christendom, and by virtue of the relationship between Church and universities, that theological concepts would intrude into natural philosophy, the overwhelmingly rational character of Aristotle's logic and natural books restricted and discouraged such intrusions, making them occasional and limited, rather than customary and extensive. Inspection of the numerous works on natural philosophy by the authors just mentioned makes it apparent that in most instances where God and matters of faith are intruded into commentaries and questions on Aristotle's natural books, they occur in one or more of five categories or contexts:

Category 1. When medieval Aristotelian commentators report opinions of Greek and Roman pagan philosophers on some issue that bears on Christian doctrine and faith; or where Aristotle himself mentions God, the gods, or something about divinity.

Category 2. Where Aristotle's arguments are contrary to Church doctrine, as, for example, on the eternity of the world, resurrection of the body, immortality of the soul, and so on. In such instances, by the statute of 1272,

which all arts masters were sworn to uphold, natural philosophers were expected to indicate that Aristotle and the faith were in opposition, or to show that Aristotle was somehow in accord with the faith. Whatever the decision, the author was required to support the faith. Also in this category, I include statements in which something is stated to be held or supported according to the faith, but where Aristotle may not be mentioned, and may or may not have been in the author's mind.

Category 3. God and articles of faith were sometimes useful in an analogical, or exemplary, sense to serve as a basis of comparison with natural phenomena, or simply to illustrate something about the natural world.

Category 4. A fourth and major source for the introduction of God and matters of faith was the Condemnation of 1277 and its aftermath. These instances were largely concerned with God's absolute power. Natural philosophers frequently found it necessary to acknowledge that God could do things that Aristotle had said were naturally impossible. Moreover they often distinguished between what God could do by His absolute power and what could be done by natural powers. When opting for the latter, they frequently used the expression 'speaking naturally' (using some form of *loqui naturaliter*). This fourth condition was operative only for the fourteenth century authors discussed here, and was not a factor for Albertus Magnus and Thomas Aquinas in the thirteenth century.

Because not all citations of God and faith fit appropriately into the four categories just described, it is necessary to add a fifth.

Category 5: Mentions of God and faith that do not fit any of the four categories just described have been placed in this fifth category, along with references to God as a cause of natural events.

In what follows, I shall refer to one or more of these five conditions as *Category 1, 2, 3, 4, or 5*, respectively.

To determine the extent to which concerns about God, faith, and theology played a role in medieval natural philosophy, I have investigated the use of some key terms in commentaries and questions on Aristotle's works that were produced by the authors mentioned above. Of these key terms, the most significant are those for God, such as *deus*, the most important of them, and some of its synonymous versions such as First Cause (*causa prima*), Prime Mover (*primus motor*), and Immobile Mover (*immobilis motor*). Although there are other interesting terms,¹⁷ I shall be concerned with only one more: 'faith' (*fides*).

¹⁷ The term 'intelligence' (*intelligentia*) occurs fairly frequently in commentaries on the *Physics*. But such occurrences are largely related to the Aristotelian association of intelligences (or angels, as they were sometimes called) as movers of celestial orbs. Only occasionally do they have theological significance.

The Thirteenth Century: Roger Bacon, Albertus Magnus, and Thomas Aquinas

Roger Bacon (ca. 1220-ca.1292) was the first, or one of the first, to lecture on Aristotle's natural books at the University of Paris after they had been banned for most of the first half of the thirteenth century. Bacon not only contributed to natural philosophy, but also encouraged the application of natural philosophy to theology and of theology to natural philosophy.¹⁸ But Bacon did not take his own advice, as is obvious by inspection of his great work on perspective. In that treatise, Bacon provides a lengthy scientific account of many aspects of the nature of light. In none of this does he mention God or the faith. His work is strictly naturalistic and rationalistic. When Bacon completed all that he would say about the science of perspective as a natural phenomenon, he turns to the faith in the final four chapters, for which he provides the general title: 'Concerning the relationship of *perspectiva* to sacred wisdom and mundane utility, in four chapters'.¹⁹ Here Bacon distinguishes between natural philosophy and science, on the one hand, and divine wisdom and faith, on the other.

Like John Pecham, Bacon wrote perspective treatises that did not include appeals to God, faith, or theology. But because perspective certified 'natural things' (*res naturales*), and Bacon was convinced that knowledge of natural things was essential for understanding divine things within and outside of sacred scripture, perspective was regarded as an invaluable discipline for a Christian. It was not only legitimate to use perspective in the service of divine wisdom, but essential to do so. In this sense, perspective (and all of natural philosophy) was regarded as a handmaid to theology. The investigation of perspective did not require the aid of theology and faith. It was to be studied for its own sake, after which one could certify what within it is useful for understanding divine wisdom.

In his *Questions on the Eight Books of Aristotle's Physics*,²⁰ Bacon includes a relatively small number of references to the deity and to spiritual entities. Of the 461 brief questions on the eight books, Bacon mentions something about God and the supernatural in only 23, or in 4.9 percent of the questions. The religious import and content in most of these 23 questions is minimal. The term God (*deus*) is mentioned in five different questions.²¹

¹⁸ See *The 'Opus Majus' of Roger Bacon*, transl. R. B. Burke, 2 vols., New York 1962; first published 1928, 73 and 65.

¹⁹ See *Roger Bacon and the Origins of 'Perspectiva' in the Middle Ages, A Critical Edition and English Translation of Bacon's 'Perspectiva' with Introduction and Notes*, ed. and transl. D. C. Lindberg, Oxford 1996, 321.

²⁰ See *Opera hactenus inedita Rogeri Baconi*, fasc. XIII: *Questiones supra libros octo Physicorum Aristotelis*, ed. F. M. Delorme, with the assistance of R. Steele, Oxford 1935. The questions are unnumbered.

²¹ See Bacon, *Questions on the Physics*, 43, 101, 125, 373, 375, and 390. Pages 373 and 375 are part of the same question.

In one of these, Bacon also mentions the Father, Son, and Holy Spirit,²² and in another he speaks of the First Cause.²³ The First Cause (*prima causa*) appears by itself in four questions,²⁴ and with other expressions, such as God and intelligences, in three more.²⁵ Not surprisingly, the term intelligence(s) (*intelligentia[e]*)—a term used frequently by Aristotle himself—appears in at least eleven questions in a role that is largely that of a motive cause for the celestial orbs and has therefore no theological significance.²⁶ Terms and concepts such as intelligence, first cause, and prime mover were so common in Aristotelian commentaries that they had lost theological significance. Indeed, the only genuine references to anything that would remind us that Roger Bacon was a Christian is a mention of Father, Son, and Holy Spirit²⁷ and, in a question as to whether Aristotle and other philosophers believe that motion has an end, his invocation of the resurrection and the faith.²⁸ Even where it became customary to introduce something about God and the faith in discussions about the infinite in the third book of the *Physics*, Bacon is silent. When we further take into account the fact that in the questions in which Bacon does mention something that seems relevant to theology, the terms, phrases, and discussions occupy only a small fraction of the questions in which they occur. Thus the percentage of theologically relevant material is miniscule.

In the 147 pages of the printed edition of Bacon's *De celestibus*,²⁹ which is based on Aristotle's *On the Heavens*, he offers thoughts about the faith on only two of those pages. A treatise on cosmology was an ideal place to intrude thoughts about God and the faith. Yet Bacon chose not to avail himself of this opportunity. What is most remarkable about the *De celestibus* is what Bacon does not say. He makes no mention of the empyrean heaven, which was a purely theological invention. One would fully expect someone as interested in the interrelations of theology and natural philosophy as was Bacon to mention this commonly accepted dwelling place of God and the elect. In his discussion of the possibility of other worlds,³⁰ Bacon, writing

²² Bacon, *Physics*, 375

²³ Bacon, *Physics*, 124.

²⁴ See Bacon, *Physics*, 126, 129, 345, and 415.

²⁵ See Bacon, *Physics*, 124, 125 (one question) and 54 and 145.

²⁶ See Bacon, *Physics*, 54, 125, 145 (twice, in two different questions), 146 (the second occurrence on p. 145 is in the same question as the occurrence on p. 146), 204-205, 207, 271-272, 331, 412, 416-418.

²⁷ See Bacon, *Physics*, 375

²⁸ See Bacon, *Physics*, 389.

²⁹ The *De celestibus* is the second book of Bacon's *Communia naturalium*. See *Opera hactenus inedita Rogeri Baconi*, ed. R. Steele, fasc. IV, 1913. The *De celestibus* extends over pages 309 to 456. The *Communia naturalium* was probably written in the late 1260s or early 1270s. See *Roger Bacon's Philosophy of Nature, A Critical Edition, with English Translation, Introduction, and Notes, of 'De multiplicatione specierum and De speculis comburentibus*, ed. and transl. D. C. Lindberg, Oxford 1983, xxv.

³⁰ See Bacon, *De celestibus*, 374.

before the Condemnation of 1277, also makes no mention of God and therefore does not suggest that by His omnipotence God could, contrary to Aristotle's denial of the possibility of other worlds, create other worlds if He so wished.³¹

Unlike Roger Bacon, who never became a theologian, Albertus Magnus and Thomas Aquinas were already masters of theology when they wrote their commentaries on the natural books of Aristotle. As professional theologians, both were free to insert thoughts about God and the faith in their treatises on natural philosophy, wherever such thoughts might be deemed appropriate. It is of importance, therefore, to see how they viewed the relations between natural philosophy and theology, and to determine the extent to which they were prepared to theologize natural philosophy. The evidence shows unequivocally that both chose to keep the theologization of natural philosophy to a minimum.

In the opening words of his commentary on Aristotle's *Physics*, Albertus declares that his Dominican brothers had implored him to 'compose a book on physics for them of such a sort that in it they would have a complete science of nature and that from it they might be able to understand in a competent way the books of Aristotle'.³² Perhaps thinking that his fellow friars would expect him to intermingle theological ideas with natural philosophy, Albertus declares that he will not speak about divine inspirations, as do some 'extremely profound theologians', because such matters 'can in no way be known by means of arguments derived from nature'. And he then explains that

Pursuing what we have in mind, we take what must be termed 'physics' more as what accords with the opinion of Peripatetics than as anything we might wish to introduce from our own knowledge (...) for if, perchance, we should have any opinion of our own, this would be proffered by us (God willing) in theological works rather than in those on physics.³³

Albertus thus believed that Aristotle's natural philosophy was to be treated naturally, in the customary manner of Peripatetics. Where theological issues might be involved, they were to be treated in theological treatises. In his *Commentary on De caelo* Albertus makes it evident that he wished to uphold his basic conviction that, unless unavoidable, theology should not be intruded into natural philosophy. In discussing whether the heaven is ungenerable and incorruptible, Albertus explains that

³¹ On the plurality of worlds, see E. Grant, 'The Condemnation of 1277, God's Absolute Power, and Physical Thought in the Late Middle Ages', *Viator* 10 (1979), 217-226; reprinted in E. Grant, *Studies in Medieval Science and Natural Philosophy*, London 1981, XIII.

³² Translated in E. Synan, 'Introduction: Albertus Magnus and the Sciences', in *Albertus Magnus and the Sciences*, ed. J. A. Weisheipl OP, Toronto 1980, 9.

³³ See Synan, 'Introduction: Albertus Magnus', 10. Synan presents the section of this passage that follows the ellipsis before the lines that precede it. But the order of the passages in Albertus's *Physics* is as they appear here.

Another opinion was that of Plato who says that the heaven was derived from the first cause by creation from nothing, and this opinion is also the opinion of the three laws, namely of the Jews, Christians, and Saracens. And thus they say that the heaven is generated, but not from something. But with regard to this opinion, it is not relevant for us to treat it here.³⁴

Because he sought to avoid theology, Albertus says that he will therefore only inquire about a third opinion,

which says that the heaven is generated from something preexisting and is corrupted into something that remains after it, just as natural things are generated and corrupted by the actions of qualities acting and being acted on mutually. And because these things alone proceed naturally and from principles of nature, we inquire about this mode, [namely] whether the heaven is generated.³⁵

Thus Albertus will speak not about the generation of the heaven from nothing, which is only possible supernaturally, but about its generation from something preexisting, which is naturally possible, even though it conflicts with a fundamental doctrine of his faith.

It is undoubtedly because of his conviction that a theologian doing natural philosophy should avoid theological discussions to the greatest extent possible that we find relatively little about God and the faith in Albertus's *Commentary on De caelo*.³⁶ The subject of the third tractate of the first book is 'whether there is one world or more' (*Utrum mundus sit unus vel plures*),³⁷ a theme that often produced mentions of God. Albertus, however, explains that

If (...) someone should say that there can be more worlds but there are not, because God could have made more worlds if He wished and even now could make more worlds, if He wishes. Against this, I do not dispute, since here I conclude that it is impossible that there be several worlds and that it is necessary that there be one [world] only. Here we understand about [i.e., we are concerned about] the impossible and necessary—that is, [we are concerned about] the world with regard to its essential and proximate causes. And there is a great difference between what God can do by means of his absolute power and what can be done in nature [or by nature].³⁸

³⁴ Albertus Magnus, *Alberti Magni Ordinis Fratrum Praedicatorum Opera Omnia*, ed. B. Geyer, *Monasterii Westfalonum in aedibus Aschendorff*, vol. 5, pt. 1, *De caelo et mundo*, ed. P. Hossfeld, 1971, bk. 1, tract. 1, ch. 8, 19, col. 2-20, col. 1. (Hereafter *Commentary on De caelo*.) Plato did not hold that the world was created from nothing. The translation is mine. Unless indicated otherwise, the translations below are mine.

³⁵ Albertus Magnus, *Commentary on De caelo*, 20, col. 1.

³⁶ As inspection of the index under 'deus' (300, col. 1) and 'fides' (304, col. 3) reveals.

³⁷ Albertus Magnus, *Commentary on De caelo*, bk. 1, tract. 3, chs. 1-10, 55-77.

³⁸ Albertus Magnus, *Commentary on De caelo*, bk. 1, tract. 3, ch. 6, 68, col. 2.

With respect 'to the nature of the world', Albertus says that 'there cannot be more worlds, although God could make more, if He wishes'.³⁹ It is not, however, what God can do that interests Albertus in his commentary on *De caelo*, but what nature can do. He concludes that nature cannot produce other worlds by its own powers. At the conclusion of the first book, Albertus emphasizes that investigators into nature do not inquire about how God uses the things He has created to make a miracle in order to proclaim his power; but, rather, they investigate 'what could be done in natural things according to the inherent causes of nature'.⁴⁰

Albertus kept theological references in his natural philosophy to a minimum, as is evident in his Aristotelian commentaries. In the 261 chapters that comprise the eight books of his *Commentary on the Physics*, Albertus mentions God (*deus* and its variants) in 24, or in approximately nine percent of his chapters; and in the 111 chapters that make up the four books of his *Commentary on De caelo*, he mentions God in 9, or in approximately 8 percent of the total. Most of Albertus's uses of the term God in his *Commentary on the Physics* are in direct response to Aristotle's text, especially in the eighth book. Thus of the 64 occurrences of *primus motor*, 55 occur in book eight; of the 69 occurrences of *causa prima*, 37 occur in book eight; and of the 78 occurrences of *deus*, 40 occur in the eighth book.

Most of these occurrences of key terms fall into *Category 1*, because they are not a defense of the faith, or about the faith as such. But Albertus unhesitatingly defended the faith against those who offered conflicting interpretations. One of the most serious claims that required a defense was Aristotle's arguments for the eternity of the world, which, if ignored, would have denied the creation. A major locus for these arguments was the eighth book of Aristotle's *Physics*, where Aristotle argued more specifically for the eternity of motion. To these kinds of arguments, Albertus replies in a chapter in which he demonstrates that the world began by a creation.⁴¹

Many mentions of the Christian God are minimal, little more than passing references, as when Albertus, in presenting eight ways in which something can be in another, says that 'sometimes it is internal, namely when form is a mover with respect to place, just as the soul in a body and God (*deus*) in the

³⁹ 'Et ideo quantum est de natura mundi, dico non posse fieri plures mundos, licet deus, si vellet, posset facere plures'. Albertus Magnus, *Commentary on De caelo*, bk. 1, tract. 3, ch. 6, 69, col. 1.

⁴⁰ 'Et ideo supra diximus, quod naturalia non sunt a casu nec a voluntate, sed a causa agente et terminante ea, nec nos in naturalibus habemus inquirere, qualiter deus opifex secundum suam liberrimam voluntatem creatis ab ipso utatur ad miraculum, quo declaret potentiam suam, sed potius quid in rebus naturalibus secundum causas naturae insitas naturaliter fieri possit'. Albertus Magnus, *Commentary on De caelo*, bk. 1, tract. 4, ch. 10, 103.

⁴¹ Albertus Magnus, *Alberti Magni Ordinis Fratrum Praedicatorum Opera Omnia*, ed. B. Geyer, *Monasterii Westfalorum in aedibus Aschendorff*, vol. 4, *Physica*, ed. P. Hossfeld, part 1 (bks 1-4), 1987; part 2 (bks. 5-8), 1993, *Commentary on the Physics*, bk. 8, tract. 1, ch. 13, 574-577. (Hereafter cited as *Commentary on the Physics*.)

world;⁴² or, in a discussion of time, when Albertus says that ‘they say that, when it is said that God is “now” (*nunc*), and an intelligence is “now”, and a motion is “now”, the same “now” is denoted’.⁴³ In the two instances just cited, Albertus’s usage conforms to *Category* 3 (see above), where theological terms and concepts are used analogically, or to exemplify and illustrate things and processes in the natural world. The parts of their respective chapters which these two instances comprise are very small indeed.

As a theologian-natural philosopher, Albertus could easily have inserted passages about God almost anywhere in his physical commentaries. For example, in his lengthy commentary on the infinite, extending over thirty-two double columned pages,⁴⁴ it might have been tempting to elaborate on God’s infinite powers. But Albertus mentions God only twice: once in a context describing the way in which Presocratic philosophers used the term infinite⁴⁵ and again, by way of example, in the first of five ways in which the infinite is described, a privative one, ‘God (*deus*) is said to be infinite (*infinitus*) and incorporeal (*incorporeus*) and immense (*immensus*)’,⁴⁶ that is, God is ‘not finite’; God is ‘not a body’; and God is ‘not measurable’. Indeed, Albert ignores a good opportunity to invoke God when, within the context of the infinite, he launches into a discussion of extracosmic space, place, and vacuum.⁴⁷ In theological treatises, it was common to involve God with space, place, and vacuum. Albertus could easily have done so had he wished. Also surprising is the fact that in his discussion of the celestial orbs in his *Commentary on De caelo*, where he speaks of ten orbs, Albertus makes no mention of the crystalline orb and the Empyrean heaven, the traditional theological spheres.⁴⁸

Thomas Aquinas (ca. 1224-1274) preserved the approach which Albertus Magnus developed toward Aristotelian natural philosophy. Like Albertus, Thomas sought to minimize theological intrusions into his commentaries on the natural books of Aristotle. The relatively few occurrences of key terms such as ‘God’, ‘faith’, ‘creation’, ‘first mover’, and ‘first cause’ in Thomas’s commentaries on the *Physics* and *On the Heavens*, and their near total absence from his commentaries on *On Generation and Corruption* (*De generatione et corruptione*) and the *Meteorology* strongly support this interpretation.

⁴² *Commentary on the Physics*, bk. 4, tract. 1, ch. 6, 211. This is the only mention of God in a lengthy chapter that extends over pages 210 to 214.

⁴³ *Commentary on the Physics*, bk. 4, tract. 4, ch. 5, 299, lines 16-18.

⁴⁴ *Commentary on the Physics*, bk. 3, tract. 2 (*De infinito*), 168-200.

⁴⁵ *Commentary on the Physics*, bk. 3, tract. 2, ch. 2, 172, lines 58-62.

⁴⁶ *Commentary on the Physics*, bk. 3, tract. 2, ch. 4, 175, lines 63-65.

⁴⁷ *Commentary on the Physics*, bk. 3, tract. 2, ch. 3, 174-175.

⁴⁸ See Albertus Magnus, *Commentary on De caelo*, bk. 2, tract. 3, ch. 11, 166-167. Also surprising is the absence of anything of a religious nature in a chapter titled ‘On the perpetuity of life that exists in the external convexity of the heaven’ (*ibid.*, bk. 1, tract 3, ch. 10, 75-77).

In Thomas's *Commentary on Aristotle's Physics*, we find almost all mentions of God and its medieval scholastic synonyms, as well as all appeals to faith, in the eighth book, a feature that is also true of Albertus Magnus's *Commentary on the Physics* (see above). Only a few isolated citations occur in the rest of his lengthy commentary. This is striking, but not startling, since Aristotle's major demonstration of a first mover in the eighth book caused Thomas, and all who commented on that book, to speak frequently of the first mover and, consequently, to find occasions to mention God. In view of long-held attitudes and opinions about the role of theology and faith in natural philosophy, the relatively few citations that Thomas made involving theology and the faith come as a surprise. When we realize that Thomas found occasion to mention God in only 21 paragraphs out of 2,550;⁴⁹ that the 54 occurrences of 'Prime Mover' and its variants occur in 43 paragraphs; that the ten usages of 'First Cause' occur in 10 paragraphs; and that matters of faith are mentioned in only 8 paragraphs. If we sum 21, 43, 10, and 8, we arrive at a total of 82 differently numbered paragraphs. Allowing for overlap in two paragraphs, the total number of paragraphs in which some version of God's name or mention of the faith appears is 80, of which 69 are in the eighth book, leaving 11 for the other seven books. The 80 paragraphs represent approximately 3 percent of the 2550 paragraphs.

To convey an idea of how Thomas used theological terms in the categories distinguished above, I shall use the data for the 21 occurrences of the term God (*deus*; four of the 21 instances appear as the term 'divine' [*divinum*]): 5 in *Category 1*; 7 in *Category 2*; 5 in *Category 3*; none in *Category 4*, which applies to the aftermath of the Condemnation of 1277, and therefore does not apply to Thomas; and 4 that I was unable to classify and therefore place in *Category 5*.

Like Albertus, Thomas also refrained from introducing theological ideas into natural philosophy. Thus in his *Commentary on De caelo*,⁵⁰ Thomas follows Albertus Magnus and makes no mention of the empyrean heaven, although both accepted its existence and found occasion to mention it in their theological treatises.⁵¹

Thomas frequently indicates where Aristotle disagrees with the faith. In 1271, however, near the end of his life, he explained why he did not often

⁴⁹ The data is drawn from *S. Thomae Aquinatis In octo libros De physico auditu sive Physicorum Aristotelis commentaria*, ed. P. Fr. Angeli-M. Pirota O.P., Naples, 1953.

⁵⁰ Thomas's commentary appears in *S. Thomae Aquinatis In Aristotelis libros De caelo et mundo; De generatione et corruptione; Meteorologicorum Expositio cum textus ex recensione leonina*, ed. R. M. Spiazzi, Turin 1952.

⁵¹ Perhaps Thomas refrained from mentioning it in a treatise on natural philosophy, because, as he explains in his commentary on the *Sentences* (bk. 2, distinction 2, qu.2, art. 1), 'the empyrean heaven cannot be investigated by reason because we know about the heavens either by sight or by motion. The empyrean heaven, however, is subject to neither motion nor sight (...) but is held by authority'. Cited from E. Grant, *Planets, Stars and Orbs: The Medieval Cosmos 1200-1687*, Cambridge, 1994, 377, n.28.

mix matters of faith with natural philosophy. In considering a question on the rational soul in man, he seemingly dismisses the question, by asserting that 'I don't see what one's interpretation of the text of Aristotle has to do with the teaching of the faith'.⁵² In Vernon Bourke's judgment, Aquinas did not think he was 'required to make Aristotle speak like a Christian' and he undoubtedly 'thought that a scholarly commentary on Aristotle was a job by itself, not to be confused with apologetics or theology'.⁵³

Natural philosophy in the fourteenth century: John Buridan, Nicole Oresme, Themon Judaeus, and Albert of Saxony

It is ironic that the four fourteenth-century natural philosophers whose works are considered here include many more references to God and the faith than did Albertus Magnus and Thomas Aquinas, who were theologians when they wrote their Aristotelian commentaries. This is perhaps partially explicable by the fact that a number of references involved the introduction of counterfactuals by way of references to the absolute power of God to do anything He pleased, short of a logical contradiction, a tactic that is especially noticeable in John Buridan's *Questions on De caelo*.⁵⁴ But the effect of the Condemnation of 1277 may have been more pervasive than the introduction of counterfactuals involving God's absolute power. God may also have been invoked to avoid the possible charge of being overly naturalistic at the expense of God's ultimate and underlying role in all events.

The increased invocation of God in the fourteenth century, however, is comparative. It seems more extensive only when compared to the natural philosophical works we have previously examined from Albertus Magnus and Thomas Aquinas. An examination of the 310 questions embedded in the five questions treatises by John Buridan, Nicole Oresme, Themon Judaeus, and Albert of Saxony shows clearly that, like their predecessors in the thirteenth century, most of their texts had little to do with God, the faith, or theology, but were concerned solely with issues in natural philosophy. Of the

⁵² 'Nec video quid pertineat ad doctrinam fidei qualiter Philosophi verba exponatur'. The translation and the Latin text are by V. J. Bourke in *St Thomas Aquinas Commentary on Aristotle's 'Physics'*, translated by R. J. Blackwell, R. Spath, and W. E. Thirkel; Introduction by V. J. Bourke, New Haven, Connecticut, 1963, xxiv. Bourke does not provide a full reference, but the statement occurs in Thomas's *Responsio ad fr. Joannem Vercellensem de articulis* 42 (43), which was printed in Aquinas's *Opera Omnia* (Parma, 1852-73; reprinted in 25 folio volumes in New York, 1948-50), vol. 16, 167. For a brief description of the treatise, see J. A. Weisheipl, *Friar Thomas d'Aquino, His Life, Thought and Work*, Garden City 1974, 390, nr. 65.

⁵³ The two quotations are from V. J. Bourke's introduction, in *St. Thomas Aquinas Commentary on Aristotle's 'Physics'*, xxiii and xxiv.

⁵⁴ See *Iohannis Buridani Quaestiones super libris quattuor De caelo et mundo*, ed. E. A. Moody, Cambridge Mass., 1942.

310 questions, 217 are free of any entanglement with the theology or faith; 93 (or approximately 29 percent) mention God and the faith. Inspection of any of the 217 questions would not reveal whether the author was Christian, Muslim, Jewish, agnostic, or atheist. Of the 93 with at least a trace of theological sentiment, 53 mention God, or something about the faith, in a cursory manner; of the remaining 40 questions, 10 have relatively detailed discussions about God or the faith.

The data show that the greatest opportunities for introducing God and the faith occurred in questions and commentaries on Aristotle's *Physics*, *On the Heavens* (*De caelo*), and *On the Soul* (*De anima*), with only modest intrusions in *On Generation and Corruption* (*De generatione et corruptione*) and the *Meteorology* (*Meteorologica*). Thus we find that in his *Questions on De caelo*, Buridan discusses God and/or the faith in 27 questions out of 59; that Albert of Saxony discusses such matters in 38 of 107 questions in his *Questions on the Physics*⁵⁵; and Nicole Oresme considers them in 18 of 44 questions in his *Questions on De anima*.⁵⁶ By contrast, Albert of Saxony and Themon Judaeus found few occasions for introducing God and faith into their *Questions On Generation and Corruption* and *Meteorologica*, respectively.⁵⁷ Albert injected such matters into 6 of his 35 questions and Themon did so in only 4 of 65 questions. In this regard, Albert and Themon were like Thomas Aquinas, who made no mention of God in his commentaries on these two treatises and who defended the faith a total of three times in both together.

It is important to see how the discussions and citations of God and the faith in the 93 questions are classifiable in terms of the five categories distinguished earlier.

Category 1	2
Category 2	12
Category 3	34
Category 4	34
Category 5	16
TOTAL	98 ⁵⁸

⁵⁵ For the full title of the work in which Albert of Saxony's *Questions on the Physics* appears, see the bibliography under Albert of Saxony.

⁵⁶ See 'Nicholas Oresme's *Questiones super libros Aristotelis De anima*': A Critical Edition with Introduction and Commentary' by Peter Marshall, Ph.D. diss., Cornell University 1980.

⁵⁷ For Albert of Saxony's *Questions on Generation and Corruption*, see the work listed under Albert of Saxony in the bibliography; for Themon's *Questions on the Meteorology*, also see the work listed under Albert of Saxony in the bibliography, where Themon's name is spelled 'Thimon'.

⁵⁸ The total is 5 beyond 93 because five questions have been recorded under two different categories. The following duplications occur: Buridan, *De caelo*, bk. 1, qu. 10 appears under *Categories 2* and *4*; *De caelo*, bk. 2, qu. 10 appears under *Categories 1* and *4*; Albert of Saxony, *Physics*, bk. 2, qu. 10, appears under *Categories 3* and *5*; *Physics*, bk. 6, qu. 9 appears under *Categories 3* and *4*; and *Physics*, bk. 2, qu. 14 appears under *Categories 1* and *5*.

It is obvious that the dominant concern of these fourteenth century natural philosophers was with *Categories* 3 and 4, which were concerned, respectively, with God used in an illustrative and exemplary sense, and with the absolute power of God. Together, these two categories extend over 68 of the 93 (or 98; see note 58) questions in which something about God and the faith arise in the five treatises. Let us now examine briefly each of the categories in the order 1, 2, 5, 3, and 4, thus reserving the most frequently occurring categories for last. Because of space constraints, I shall include only one example from categories 1, 2, and 5, two from category 3 and more than two from category 4, which is the most interesting categorical use of God in fourteenth-century natural philosophy.

Category 1: The reaction to Aristotle's mention of God

In *On Generation and Corruption* (2.10.336b.25-35; Oxford translation), Aristotle declares that God 'fulfilled the perfection of the universe by making coming-to-be uninterrupted for the greatest possible coherence would thus be secured to existence, because that coming-to-be should itself come-to-be perpetually is the closest approximation to eternal being'. In reaction to this passage, Buridan explains that Aristotle 'wishes to declare here and in the second [book] of *De generatione* how such an order is reasonably from God and how all existing things from God, both celestial and inferior, are harmonious with regard to that order that is to be perpetually conserved'.⁵⁹ Buridan invokes God here in direct response to Aristotle's comments.

Category 2: Invocation of God and faith against the doctrinal errors of Aristotle and the philosophers

In his *Questions on De caelo*, in a question concerned with generable and corruptible things, Buridan declares that

Aristotle says many things that cannot be properly saved (...) For he holds indeed that nothing corruptible, or having potency for not being, can always exist in the future; and this is in fact false and against the faith because all things except God are corruptible and at some time they are not and are not able to be because they could be annihilated by God. And yet many things are perpetuated and always remain.⁶⁰

⁵⁹ Buridan, *Questions on De caelo*, bk. 2, qu. 10, pp. 171-172.

⁶⁰ Buridan, *Questions on De caelo*, bk. 1, qu. 26, p. 127.

Category 5: Mentions of God that do not fit any of the other four categories

In asking 'whether for perfectly understanding something it is necessary to know all its causes',⁶¹ Albert of Saxony offers eight principal arguments against this proposition. In the second of these, he presents the following proof: 'For God is the cause of any whatever thing. Therefore for the perfect understanding of any thing, it is necessary to know God. But since God could not be perfectly known by us, it follows that no thing can be known perfectly by us if, in order to have perfect cognition of anything, it is necessary to know all causes'.⁶² In his reply to this argument at the end of the question, Albert says: 'To the second, I similarly concede that for the perfect cognition of anything, it is absolutely necessary to know God. However, this is not required for perfect cognition in the genus of something'.⁶³ Since this is a discussion about the role of God in understanding things, it does not fit any of the other categories. We should note, however, that Albert argues that we can have perfect cognition of something within a genus, even without perfect knowledge of God.

Category 3: God as example, analogy, and basis of comparison

In his *Questions on De anima*, Nicole Oresme uses God for illustrative purposes a number of times, occasionally inserting a few within a short space. In a supposition, he declares 'that some power makes this or that operation anew without changing itself, just as is obvious with God who continuously produces new effects without any change in Himself'.⁶⁴ Themon Judaeus employs God in a similar comparative manner, when he assumes that 'a pure element is understood [to be] simple, but not simple absolutely, as is God, or an intelligence'.⁶⁵

Category 4: God's absolute power

In a question inquiring whether every extended thing is a quantity, Albert of Saxony invokes God's absolute power to show that this is not necessarily so. He assumes a given quantity, which he calls *a*, *b* and *c*, and then argues that 'God can separate, without local motion, any whatever thing that is distinct from another thing. Therefore God can separate a quantity from extended

⁶¹ Albert of Saxony, *Questions on the Physics*, bk. 1, qu. 3, fols. 2r, col. 2-3r, col. 1.

⁶² Albert of Saxony, *Questions on the Physics*, bk. 1, qu. 3, fol. 2r, col. 2.

⁶³ Albert of Saxony, *Questions on the Physics*, bk. 1, qu. 3, fol. 3r, col. 1.

⁶⁴ Nicole Oresme, *Questions on De anima*, bk. 3, qu. 2, 517 of Marshall's edition.

⁶⁵ Themon Judaeus, *Questions on the Meteorology*, bk. 4, qu. 5, fol. 213v, col. 1.

thing *a*, *b* and *c*'.⁶⁶ Elsewhere, Albert assumes that 'God could create another body around this world; and around that body [He could] create another body; and so to infinity. Nevertheless, these bodies are not mutually continuous'.⁶⁷

In another question, Albert emphasizes God's power to make a greater magnitude than any given magnitude.⁶⁸ In book three, question twelve, Albert mentions God about ten times, all of them relevant to his assumption that God can make an infinite weight by creating a one-foot stone in every proportional part of an hour, and to his assumption that God can annihilate all matter lying between the concave orb of the moon.⁶⁹ Albert uses the idea of annihilation again, when he imagines what would happen if God created a vacuum by annihilating all the matter lying between the walls of a pipe (*fistula*).⁷⁰ In another question,⁷¹ Albert invokes God's absolute power in a number of contexts related to local motion. Once again, he assumes that God annihilates matter, this time annihilating all celestial bodies except one, the moon, which rotates from east to west. The challenge is to explain how a body that has no bodies external to it may be said to be in motion. In the same question, Albert also assumes that God could fuse all the celestial orbs, along with all bodies and matter below the moon, into one continuous whole, which He sets into rotation from east to west, or in any way He pleases. Once again, Albert seeks to explain how we are to understand a motion that does not relate in any way to anything outside of itself. In responding to the third principal argument of the same question, Albert places the only limitation one could place on God: not even God could do anything that implies a contradiction.

Similar declarations appear in John Buridan's *Questions on De caelo*, a treatise that offered many opportunities to insert claims about God's absolute power. For example, Buridan argues that 'although it is not possible by natural powers that a plurality of motions not exist, it is, nevertheless, not absolutely impossible, because God could make the whole heaven rest'.⁷² In discussing the empyrean heaven, Buridan says of this immobile heaven beyond the movable heavens that 'according to nature [it] does not have any potency or inclination for motion, although it could be moved supernaturally by God Himself, just as all things, except God Himself, could be annihilated by God'.⁷³ Indeed, as an illustration of God's absolute power, adopted directly from article 49 of the Condemnation of 1277, both Buridan and

⁶⁶ Albert of Saxony, *Questions on the Physics*, bk. 1, qu. 6, fol. 5r, col. 2.

⁶⁷ Albert of Saxony, *Questions on the Physics*, bk. 3, qu. 11, fol. 39r, col. 2.

⁶⁸ Albert of Saxony, *Questions on the Physics*, bk. 3, qu. 14, fol. 42r, cols. 1 and 2.

⁶⁹ Albert of Saxony, *Questions on the Physics*, bk. 3, qu. 12, fols. 39v, col. 1-40v, col. 2.

⁷⁰ Albert of Saxony, *Questions on the Physics*, bk. 4, qu. 12, fol. 51r, col. 1.

⁷¹ What follows in this paragraph appears in *Questions on the Physics*, bk. 3, qu. 6, fols. 35v, col. 1-36r, col. 1.

⁷² Buridan, *Questions on De caelo*, bk. 2, qu. 10, 170.

⁷³ Buridan, *Questions on De caelo*, bk. 2, qu. 6, 152.

Nicole Oresme assumed that God could move the entire world with a rectilinear motion.⁷⁴

And going beyond our world, beyond the last immobile empyrean heaven, Buridan declares that 'it must be conceded that outside this world, God could easily create a corporeal space and however many corporeal bodies He pleases; but [just] because of this [namely that He could do it], it should not be assumed that He did it'.⁷⁵ Among the things that God could make beyond our world are other worlds. Buridan counters Aristotle's arguments against the possibility of other worlds by insisting that 'we know from faith that God could make a world, indeed many worlds, and He is also able to destroy them again'. Buridan proclaims that 'successively different worlds could be made by divine power, but not by natural power because celestial bodies are not generable or corruptible by natural powers'.⁷⁶

God's absolute power had one monumental obstacle that scholastic ingenuity never surmounted. Could God create an infinite magnitude, or an infinite perfection? Buridan argues that not even God could perform these acts. 'I believe', he declares, 'that God cannot make a body so great but that He could not make a greater body, nor that He could make a thing so perfect that He could not make one even more perfect'.⁷⁷ For this reason, Buridan insists that 'it is not possible even by the power of God that an infinite body with respect to magnitude [be created], nor [can He make] an effect according to infinite perfection'.⁷⁸ Thus if God could create an infinite body or perfection, His power would thereafter be limited, since not even God could create something greater than an infinite. But His power is also limited if He cannot create an infinite body or perfection. Scholastics argued this point for centuries without resolution.⁷⁹

The extensive use of the concept of God's absolute power in fourteenth-century natural philosophy gave rise to many counterfactual examples. To avoid even the hint of placing limits on God's omnipotence, natural philosophers assumed that God could create as many other worlds as He pleased, that He could move our world with a rectilinear motion, that He could separate a quantity from its extension, and so on. Indeed, it was always assumed that God could do anything whatever short of a logical

⁷⁴ See Buridan, *Questions on De caelo*, bk. 1, qu. 16, 75-76 and Oresme, *Questions on De anima*, bk. 2, qu. 15, 386.

⁷⁵ Buridan, *Questions on De caelo*, bk. 1, qu. 17, 79.

⁷⁶ For the Latin text of these two passages, see Buridan, *Questions on De caelo*, bk. 1, qu. 19, 89. Article 34 of the Condemnation of 1277, denounced the opinion that God could not create other worlds. See Grant, *Planets, Stars, and Orbs*, ch. 8 ('The possibility of other worlds') and p. 151 for article 34.

⁷⁷ Buridan, *Questions on De caelo*, bk. 1, qu. 17, 79. Buridan makes much the same argument in his *Questions on the Physics*, bk. 3, qu. 15; see Grant, *Planets, Stars, and Orbs*, 111.

⁷⁸ Buridan, *Questions on De caelo*, bk. 1, qu. 17, 79.

⁷⁹ See Grant, *Planets, Stars, and Orbs*, 106-110, especially p. 110.

contradiction, and therefore that He could do anything that was naturally impossible in Aristotle's world. For anyone who views medieval natural philosophy as about God and the creation, the medieval preoccupation with counterfactuals poses a dilemma: counterfactuals are not about creation. They are about things God could have done, and could do now, but which virtually nobody thought He had done, or would do. Counterfactuals subvert the assertion that natural philosophy is always about God and the creation. Even the part of natural philosophy that is about the world that God created—and which all happily acknowledged that He had created — was not investigated in order to determine God's nature, to learn about the faith, or to discover religious aspects of the created world. The paucity of material on these themes in the treatises discussed here is striking, if mute, testimony to these claims.

Conclusion

The evidence presented here reveals that medieval natural philosophers who explicated the texts of Aristotle's natural books kept their inevitable involvements with God and the faith to a minimum. This is especially true in the thirteenth century, when such famous Dominican theologians as Albertus Magnus and Thomas Aquinas, who wrote their commentaries on Aristotle's natural philosophy after they had become masters of theology, refrained remarkably from intruding theology into their natural philosophy.

Roger Bacon is even more surprising, because he explicitly advocated intermingling theology and natural philosophy. But when opportunities arose to mix the two, he rarely did so.

The Condemnation of 1277 compelled fourteenth-century natural philosophers, most of whom were secular arts masters when they wrote their relevant treatises, to invoke God's absolute power to do many things that were naturally impossible in Aristotle's natural philosophy and, at the same time, to make certain that Aristotle's contrary-to-faith concepts were plainly identified as errors. Despite these constraints, the overall impact of specific ideas about God and the faith are quite modest and should not alter the conception that the content of fourteenth-century natural philosophy was fundamentally about natural phenomena studied in a rational and secular manner to the fullest extent possible.

No one exemplified this approach better than John Buridan. As a natural philosopher, Buridan was aware that his objective was to describe and explain nature's operations in terms of natural causes and effects, and not to explicate God's supernatural actions and miracles. Buridan had no problems with his faith. He accepted the truths of revelation as absolute, and acceded to them. But in keeping with the tradition of his fellow natural philosophers, he acknowledged that his task was to explicate problems about natural actions and phenomena, and not to deal with the supernatural. In treating a

question as to whether every generable thing will be generated, Buridan immediately acknowledges that one can treat this problem naturally—‘as if the opinion of Aristotle were true concerning the eternity of the world, and that something cannot be made from nothing’—or supernaturally, wherein God could prevent a generable thing from generating naturally by simply annihilating it. ‘But now’, Buridan declares, ‘with Aristotle, we speak in a natural mode, with miracles excluded’.⁸⁰ Buridan believed that truth was attainable when ‘a common course of nature (*communis cursus nature*) is observed in things and in this way it is evident to us that all fire is warm and that the heaven moves, although the contrary is possible by God’s power’.⁸¹ Natural philosophers like Buridan were usually careful to concede that God could upset the natural order of things by direct intervention. That is why an expression such as the ‘common course of nature’ was so useful. Natural philosophers were primarily interested in natural, not supernatural, powers, for which reason Buridan insisted that ‘in natural philosophy, we ought to accept actions and dependencies as if they always proceed in a natural way’.⁸² Although, by His absolute power, God could move an infinite body, Buridan regards it as obvious that Aristotle’s arguments ‘conclude sufficiently with respect to natural powers’.⁸³ If he had to concede that God could use His absolute, unpredictable power to produce any natural impossibilities He wished, Buridan could still save Aristotle and natural philosophy by characterizing Aristotle’s arguments as sufficient in the real, natural world, the one he and his fellow natural philosophers sought to understand.

To underscore the fact that medieval natural philosophy was about the natural, not supernatural, operations of the world, it is important to recognize that in almost any given question (*questio*), the invocations of religious or theological material usually occupy a small percentage of the total question. Let us recall that of the 310 questions in the five treatises that formed the basis of our investigation of Aristotelian natural philosophy in the fourteenth century, 217 had nothing whatever on God or the faith and only 93 did. Of the 93, however, most had relatively little on theology. For example, in his *Questions on the Physics*, Albert of Saxony asks whether ‘from the addition

⁸⁰ See Buridan, *Questions on De caelo*, bk. 1, qu. 25 (*Utrum omne generabile generabitur*), 123.

⁸¹ From Buridan. In *Metaphysicen Aristotelis*, (Paris, 1518, bk. 2, qu. 1 (‘whether the grasp of truth is possible for us’), fol. 8v, col. 2-9r, col. 1. The translation is by E. Sylva, ‘Galileo and Probable Arguments’, in *Nature and Scientific Method, Studies in Philosophy and the History of Science*, ed. D. O. Dahlstrom, vol. 22, Washington D.C. 1991, 216. Cited in E. Grant, ‘Jean Buridan and Nicole Oresme on Natural Knowledge’, *Vivarium*, 31 (1993), 88.

⁸² ‘Modo in naturali philosophia nos debemus actiones et dependentias accipere ac si semper procederent modo naturali, (...)’ Buridan, *Questions on De caelo*, bk. 2, qu. 9, 164. Also cited in Grant, ‘Jean Buridan and Nicole Oresme on Natural Knowledge’, *Vivarium* 31 (1993), 89.

⁸³ ‘Et sic manifestum est quod rationes Aristotelis sufficienter concludunt quantum ad potentias naturales’. Buridan, *Questions on De caelo*, bk. 1, qu. 17, 77.

of some whole to some whole another whole is made; similarly, [whether] by the removal of some whole from some whole, another whole is made'.⁸⁴ Of the 201 lines of text in this question, 10 are devoted to the fourth and fifth (of ten) principal arguments in which Albert rejects the proposition as follows:

Fourthly, it would follow that none of us would be baptized. But this is false and the consequence is proved because many particles are added to us. And thus we are greater than when we were baptized. Therefore by addition of some part to the whole there occurs another whole. Therefore it follows that none of us is the same whole which we were in [our] youth, and, consequently, none of us is that [person] which was baptized.

Fifthly, by similar reasoning, it would follow that none of us is the one who was born of his mother, just as Christ was not the same man who was suspended on the cross and who was born of the purest virgin.

Not only do these arguments constitute a small portion of the whole question—slightly less than five percent—but the discussions about baptism and Christ are examples, and could have been replaced by other examples of a non-religious character. Moreover, within the structure of a typical question, the principal arguments and the responses to them at the beginning and end of the question, respectively, represent the least important parts. Between them lies the body of the question in which the author presents the main conclusions and qualifications. In the question we are discussing, the religious component occurs only in the principal arguments (indeed Albert does not even respond to them) and not in the body of the question. Thus they play no significant role in the question.

Because fewer than one-third of the 310 questions considered here had theologically relevant material, and most include much less than five percent that pertains to God, the faith, or church doctrine (indeed more than half of the references are little more than passing mentions of God or some aspect of the faith and play insubstantive roles in their respective questions), we may rightly conclude that God and faith played little role in medieval natural philosophy. If natural philosophy was really about God and His creation, why did medieval natural philosophers virtually ignore these themes in their questions? The answer is obvious: because they were irrelevant to their objective, which was to provide natural explanations for natural phenomena. Perhaps, the most important reason why theology did not significantly penetrate natural philosophy is simply that while theology needed natural philosophy, natural philosophy did not need theology.

⁸⁴ Albert of Saxony, *Questions on the Physics*, bk. 1, qu. 8, fols. 7r, col. 2-8r, col. 1. The translation is from Grant, *Source Book in Medieval Science*, Cambridge Mass. 1974, 200.

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KEITH HUTCHISON

A STRANGE FACT ABOUT ARISTOTELIAN DYNAMICS

The message pursued in this note is very simple, albeit initially quite implausible: standard peripatetic physics, I observe, is incompatible with a stationary Earth. For if the Earth is presumed motionless, the stellar appearances require celestial rotations wildly inconsistent with Aristotle's dynamics. They contradict indeed the Aristotelian insistence that as a matter of physical necessity, stars circle the centre of the Earth. In consequence, the dynamics of the celestial region clash with its kinematics (in much the same way as is already familiar with Ptolemy's epicycles). To save the appearances, a non-canonical physics is required, where forced motions (not centred on the Earth) are accepted in the heavens—as Aristotle himself half-admits.

To see the inconsistency here we need do very little—just attend carefully to the observed rotation of individual stars, and agree this is quite different to motion around the centre of the Earth. Consider a star close to the North Celestial Pole, Polaris for instance. This star barely seems to move at all; such observed motion as it reveals takes place in a small circle, very near the stationary Pole. If Polaris possessed a real motion that took it right around a stationary Earth (as peripatetic dynamics seems to require), its apparent motion would be radically different. It would, in particular, move well away from the North Celestial Pole, for this does not move at all; and every day, Polaris would appear in the extreme south of the sky, for its motion along a great circle would take it very close to the South Celestial Pole.

Furthermore, if every other star were presumed to be moving similarly—around the stationary Earth—the stars would take on the appearance familiar to us today from artificial satellites: there would be no fixed constellations; and the distinction between planet and star would require major reformulation. Such appearances are so different from what is actually seen, that no one has ever *believed* the stars circle the Earth. Aristotle certainly did not believe it—despite what he *professes* when setting out his dynamics!

For Aristotle's explanation of the stellar appearances is well known. He explains the apparent motion of a star by giving it a real motion, motion on a circle parallel to the equator, tracing one revolution per sidereal day. He adopts in particular the two-sphere model of the universe, and permanently attaches each star to a rigid sphere which rotates on an axis passing through

the Earth. In consequence very few individual stars orbit the centre of the Earth. In further consequence, the motions of the stars adopted by Aristotle requires a physics somewhat different from that which Aristotle (and his followers) endorse.

In the case of Polaris, the motion allocated is on a small circle, very close to the North Celestial Pole. The centre of this star's orbit is clearly nowhere near the Earth. With other stars, the centre of the orbit is much closer the Earth, but only a tiny minority of stars—those above the Earth's equator—are given a motion centred on the Earth. The others have their centres more or less remote from the Earth—at various localities on the line joining the North and South Poles. We can be certain that Aristotle realised this, for in *On the Heavens* II.8 he explicitly discusses one simple consequence of this distribution of the centres, the fact that fixed stars do not all travel on orbits of the same size. So Aristotle is certainly committed to stellar motions eccentric to the Earth, even if such motions clash sharply with the causal explanations he provides for them.

More precisely, the clash detected here is between the interpretation of the kinematics sketched above, and an interpretation of Aristotle's physics—as requiring all celestial motions to take place on circles centred in the Earth. Neither of these interpretations is controversial, and both are traditional—yet the second is faced with some minor problems. So let us review the evidence for it systematically, checking that Aristotle declares: the heavens to contain nothing but aether; this aether to undergo no change beyond natural motion; and all such unforced motion to be in circles centred on the Earth. In simple consequence of these doctrines, all motion in the heavens has to be centred on the Earth.

We begin with the composition of the heavens. According to Aristotle, the superlunary world is entirely composed of a single material element, referred to by a variety of descriptions, such as 'the primary body', or the 'aether', etc.¹ There has to be a special non-terrestrial element (he says) because there are three types of simple motion possible 'either away from or towards or about the centre'. Yet the last of these would be missing from a universe composed of the four terrestrial elements alone, so 'there must necessarily be some simple material which moves naturally and in virtue of its own nature with a circular movement'.²

¹ For a listing of the descriptions given to this element by Aristotle, see *Averroes's De substantia orbis: Critical Edition of the Hebrew Text with English Translation and Commentary*, ed. A. Hyman, Cambridge, Mass. 1986, 39-40, n.2.

² *On the Heavens* I.2, (quoting from 268b20-25, 269a5-10). For details of the Oxford/Barnes translations used throughout this essay, see bibliography. Often however, I replace that edition's conventional translation of σῶμα as 'body' with 'material', because of the need below (p.278) to distinguish an 'object' from the 'stuff' of which it is made. The English word

Furthermore, 'the whole world of the upper motions is full of that material' (*Meteorology* I.3, quoting from 339b15-20). One reason there can be no other materials in the superlunary region is that the other elements have different types of natural motion, yet the only motion observed in the heavens is circular. This fact also supports Aristotle's closely-related insistence that aether is genuinely different from the other elements. 'On all these grounds (...) we may infer with confidence that there is something beyond [the sublunary elements] (...), different and separate from them; and that the superior glory of its nature is proportionate to its distance from this world of ours' (*On the Heavens* I.2, quoting from 269b10-20).

These are not just his own personal opinions, declares Aristotle (somewhat unreliably). Indeed, the idea that the heavens are made of aether 'appears to be an old belief'. 'Men seem to have assumed that a body that was eternally in motion was also divine in nature; and as such a body was different from any of the terrestrial elements, they determined to call it "aether"'.³

This 'ancient' belief, that the heavens are divine, seems to lie behind the second of the doctrines we are seeking to document here, the thesis (clearly presumed in the arguments above) that all motion in the heavens is natural, or equivalently, that force only acts below the moon. Aristotle repeatedly emphasises this claim—even though it is also true (as we later observe) that he sometimes equivocates on the details, perhaps even retracting part of his teaching here. The reason for the stress is obvious: the doctrine is important to Aristotle's world-view, for it provides a defence of the immutability of the heavens. It thus supports in turn the fundamental idea that the heavens are markedly distinct from the ever-changing terrestrial world, unageing, immortal, divine even—or perhaps just a material ersatz for the divine.⁴ 'For (...) all who believe in the existence of gods (...) agree in allotting the highest place to the deity (...) If then there is, as there certainly is, anything divine, what we have just said about the [immutability of the aether] was well said' (*On the Heavens* I.3, quoting from 270b5-15).

The theological overtones of this restriction of force to the sublunary world are well illustrated in the Pseudo-Aristotelian *On the Universe*. For this text contrasts 'the ethereal and divine nature' which is 'orderly and (...)

'body' blurs this distinction. For the difficulties of translating σῶμα, see 'Introduction' to Aristotle, *On the Heavens*, transl. W. K. C. Guthrie, London 1939, xii.

³ *Meteorology* I.3, quoting from 339b20-30. For Aristotle's historical unreliability, see M. R. Wright's discussion of applications of the term 'aether' before Aristotle, in *Cosmology in Antiquity*, London 1995, 109-125.

⁴ Cf. F. Solmsen, *Aristotle's System of the Physical World: a Comparison with his Predecessors*, Ithaca 1960, 289-290; D. Furley, *Cosmic Problems: Essays on Greek and Roman Philosophy of Nature*, Cambridge 1989, 9.

free from disturbance, change, and external influence' with fire 'which is subject throughout to external influence and disturbance and is, in a word, corruptible and perishable (...) Beneath [fire] spreads the air, (...) [and this] too admits of influence and undergoes every kind of change'. Then come water and earth. 'All the upper portion represents the dwelling of the gods, the lower the abode of mortal creatures' (392a30-393a5).

Aristotle similarly tells us that the reason we know there is no fire in the heavens, is that for fire to move in a circle would require force. And force is ruled out by the fact that the celestial motions are ever-lasting: 'it would be remarkable and indeed quite inconceivable that this movement alone should be continuous and eternal, given that it is unnatural (*παρά φύσιν*) (...) It is the unnatural which quickest passes away' (*On the Heavens* I.2, quoting from 269b5-15).

Not only is the everlasting circular motion of the heavens natural, but for Aristotle there is no other motion in the heavens, so there can be no forced or artificial motion of any kind in the superlunary region, circular or not.

Constrained movement would necessarily involve effort—the more so the more eternal it were—and would be inconsistent with perfection. Hence we must not believe the old tale which says that the world needs some Atlas to keep it safe (...) Nor again, is it possible that it should persist eternally by the necessitation of a soul. For a soul could not live in such conditions painlessly or happily, since the movement involves constraint, being imposed on the first body whose natural motion is different, and imposed continuously (...) On this hypothesis alone are we able to advance a theory consistent with our premonitions of divinity (*On the Heavens* II.1, 284a15-b5).

As I have already suggested however, there are several occasions on which Aristotle seems to retreat from this insistence that the heavens contain nothing but natural motion. One of these is reported by Cicero, who describes Aristotle as taking the view that all natural motions are up or down, and not allowing (in what is apparently an early dialogue, *On Philosophy*) a separate celestial element. If this report is accurate, Aristotle at one stage categorised the stellar motions as 'voluntary' rather than natural.⁵ In doing this however, he maintained the claim that we care about here: the stellar motions are still unforced and (apparently) self-generated. So the first of our exceptions is a red herring for us—though the notion in question seems to have exerted a long influence in other directions.⁶

⁵ Aristotle, fragment 24 R³ (from Cicero, *De natura deorum* II.xvi.44) transl. J. Barnes and G. Lawrence, in: Aristotle, *Complete Works*, ed. Barnes, vol. 2, 2396. For the identification of Cicero's source, Guthrie, 'Introduction', xxv-xxvi; and H. Rackham's notes on pp. 34, 158, 162, 164 to Cicero, op. cit., transl. H. Rackham, London 1933, I.xiii.33, II.xiii.37, II.xv. 42, II.xvi. 44.

⁶ J. D. North, 'Celestial Influence—the Major Premiss of Astrology', *'Astrology hallucinati': Stars and the End of the World in Luther's Time*, ed. P. Zambelli, Berlin, 1986,

Another of Aristotle's 'retractions' is his insistence (in *On the Heavens* II.8) that the stellar motions are not self-caused. This equivocation is of considerable significance here, for it reveals some recognition on Aristotle's part of the problem that motivates this essay, so will be examined further below. It can be ignored for the moment, however, because there can be no doubt that Aristotle did not himself acknowledge the analysis in question as withdrawing the insistence that the stellar motions are natural.

The last of Aristotle's apparent retreats is his familiar insistence that ethereal motions are externally maintained through the activity of various unmoved movers (e.g. *Metaphysics* XII [= Λ].7-9). Such activities might be taken as suggesting that the aether does, after all, suffer force and change. Indeed as Aristotle's ideas develop,⁷ the movers of the *Metaphysics* seem to become the real owners of the immutability and divinity noted earlier as being accorded (in *On the Heavens* I.2-3 and II.1) to the celestial region and its material constituent, aether. Such 'impassive and unalterable' movers are certainly distinct from the element aether, for they are substances that are 'separate from sensible things (...) without parts and indivisible (...)'
(*Metaphysics* XII [= Λ].7, quoting from 1073a1-15). So there is no doubt the movers are external to the aether, yet their prime function is to create effects—movement—in that aether (ibid., 1072a20-25). For it is a fundamental principle of Aristotle's physics that everything in motion requires a mover that is separate from it (*Physics* VII.1, 241b20ff.). So the aether does not seem to be free of all effort, *pace* Aristotle's claim above (*On the Heavens* II.1, 284a15-20).

Such facts certainly create much uncertainty in us about what Aristotle means by 'natural' motion, for he seems to insist that it proceeds both with and without an external mover. But these facts do not detract from the conclusion that the motion of the aether is natural, for there is no doubt that when Aristotle insists on a separate mover he intends to include natural (and even animal) motions within the requirement. He admits (in, e.g., *Physics* VII.1 and VIII.4) it is more difficult to recognise the external mover in the case of natural motion; but close analysis shows that it is still there. So even if aethereal motion is to be understood as externally maintained, all the motion found in the heavens remains (on the evidence so far examined) that which is natural to aether, i.e. rotation.

But does this natural rotation of aether have a single centre, and if so what is it? I cannot find Aristotle answering this question *directly*, but he

45-100, esp. 47; n.28 of K. Hutchison, 'The Occult, the Natural and the Supernatural in the Scholastic Universe', forthcoming in *1543 and All That*, ed. A. Corones and G. Freeland, Dordrecht.

⁷ Guthrie, 'Introduction', xv ff.; D. R. Dicks, *Early Greek Astronomy to Aristotle*, London 1970, 211-213.

strongly implies what he is usually taken to mean, viz. that there is one centre, the centre of the Earth.⁸ In *On the Heavens* II.8 for instance, he briefly mentions that the orbits (or stars) all move about the same centre (περί το αὐτό κέντρον, 289b30-35). And in II.3, he deduces the existence of a central Earth from the rotation of the aether.⁹ There has to be some material object stationary at the centre of such a rotation, he says (286a10-25): 'Earth then has to exist; for it is earth which is at rest at the centre [ἐπὶ τοῦ μέσου]'.¹⁰ In an earlier section (I.2, already mentioned above), he had similarly deduced the existence of aether from an analysis of simple motions, whose simplicity requires them to be 'either away from or towards or about the centre [περί το μέσον]' (268b20-25). The former two of these motions are provided by the natural motions of the four terrestrial elements, so there has to be a further element to supply the last of them. The centre in question here is clearly the centre of the universe, for that is where the motions of the sub-lunary elements are directed.¹¹ When Aquinas commented on this passage (in the thirteenth century) he made this explicit: 'by "about the centre" is to be understood "about the centre of the world"'. Maimonides had said much the same thing, late in the twelfth century: 'It is a fundamental principle of this world that there are three motions: a motion from the midmost point of the world, a motion towards that point, and a motion around that point'.¹²

⁸ For some examples of this interpretation of Aristotle see T. Kuhn, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*, Cambridge, Mass. 1957, 244; Furley, *Cosmic Problems*, 7-9; O. Pedersen, *A Survey of the Almagest*, Odense 1974, 34; P. Duhem, *To Save the Phenomena. An Essay on the Idea of Physical Theory from Plato to Galileo*, transl. E. Doland and C. Maschler, Chicago 1969, 15, 41; E. Grant, *Planets, Stars, and Orbs: The Medieval Cosmos, 1200-1687*, Cambridge 1994, 298; idem, 'Eccentrics and Epicycles in Medieval Cosmology', *Mathematics and its Applications to Science and Natural Philosophy in the Middle Ages*, ed. E. Grant and J. Murdoch, Cambridge 1987, 189-214, esp. 195; W. H. Donahue, *The Dissolution of the Celestial Spheres 1595-1650*, New York 1981, 15. For some implicit endorsements of the interpretation, see also n. 16 below.

⁹ As indicated in my quotations, Aristotle uses different Greek words (κέντρον, μέσον) for the 'centres' discussed in these arguments. I cannot tell whether there is any significance in this fact. I note below that (on at least one occasion, 296a25-30) he uses μέσον to refer to what is clearly an axis rather than centre. Yet at 296b5-10 he uses the two words seemingly interchangeably; while Guthrie observes that Aristotle is careless with words in general, and with μέσον in particular: see his n.a on pp.46-7 of the Loeb *On the Heavens*.

¹⁰ It might seem that this argument in favour of the motions being centred on the Earth can be avoided, if Aristotle be interpreted as requiring only that stationary matter be found somewhere on the axis of rotation. But if that were what Aristotle meant, the whole discussion would be pointless and redundant. For the axis of rotation certainly intersects the celestial sphere at the North Celestial Pole, so automatically contains some stationary matter. The proposed interpretation would make Aristotle's requirement so weak here, that his argument could not possibly reach its intended goal—demonstration of the existence of the Earth.

¹¹ *On the Heavens* II.14, IV.4 (296b5-25, 312a1-5).

¹² For Aquinas, T. Litt, *Les corps célestes dans l'univers de Thomas d'Aquin*, Louvain 1963, 342-343. For Maimonides, M. Maimonides, *The Guide of the Perplexed*, II.24, transl. and annot. S. Pines. Chicago 1963, 322-327, esp. 323.

Aristotle's silence here suggests he is not personally committed to the view attributed to him by his followers, that all celestial motions take place in earth-centred orbits, yet this interpretation does seem to be the only one allowed by what he writes. The conflict we are observing necessarily involves the usual uncertainties of interpretation, but the evidence now assembled for that interpretation is certainly good. More importantly (as Aquinas and Maimonides indicate—together with numerous modern commentators¹³, the problematic interpretation certainly became traditional.

Indeed, after making the remarks just noted, both Aquinas and Maimonides went on to cite the standard scholastic view that the devices of Ptolemaic astronomy are incompatible with Aristotle's physics—because they require portions of the aether to rotate about points which are not the centre of the Earth. What they were referring to here is quite clear—for Ptolemy allows planets to move on epicycles whose centres are quite remote from the Earth; while those centres themselves move on overtly eccentric deferents (with speeds that are, to boot, varying). Ptolemaic devices, explained Maimonides:¹⁴

are entirely outside the bounds of reasoning and opposed to all that has been made clear in natural science (...) The revolution of the epicycles is not around the center of the world (...) If epicycles exist, theirs would be a circular motion that would not revolve round an immobile thing (...) If what Aristotle has stated with regard to natural science is true, there are no epicycles or eccentric circles and everything revolves round the center of the earth (...) How can one imagine a rolling motion in the heavens or a motion around a center that is not immobile?

Copernicus confirms the persistence of such views well into the sixteenth century, by pausing to reject them. The motions of the planets make it patent—he insists¹⁵—that celestial motions have multiple centres.

This concern is only plausible to those who accept the interpretation of Aristotelian theory urged here. Indeed, the clash with Ptolemy would be drastically reduced if Aristotelian theory did not single out a preferred centre for ethereal orbits (though the problematical status of the equant would still remain). The prevalence of the medieval complaints about Ptolemy—together with the general consensus of the secondary literature, that the complaints make sense—confirms the claim that our interpretation of Aristotle did indeed become traditional.¹⁶

¹³ See notes 8 and 16.

¹⁴ Maimonides, *The Guide of the Perplexed*, II.24, 322-326.

¹⁵ N. Copernicus, *On the Revolutions of the Heavenly Spheres* I.9, transl. and annot. A. Duncan, Newton Abbot 1976, 46.

¹⁶ For examples (and endorsements) of the complaint about the introduction of eccentric celestial motion, see the extended discussion in Duhem, *To Save the Phenomena*, esp. 15,

The kinematics of Ptolemy's system—the motions he attributes to the planets—are thus quite incompatible with a standard interpretation of Aristotle's celestial dynamics. But we can now conclude that a similar clash occurs with the motions attributed to fixed stars by Aristotle himself. The dynamics declares there is only one category of motion above the moon, the natural motion of aether—in circular orbits centred on the Earth. Yet this is not the motion allocated to the stars—circular orbits parallel to the Earth's equator. So Aristotle's celestial kinematics requires each non-equatorial star to undergo a motion differing from that which the dynamics declares its material to undergo.

The clash between Aristotle and Ptolemy is, of course, much greater than the clash internal to Aristotle. Ptolemy's equants introduced celestial motions of varying speed; while his eccentrics required aether to approach the Earth and recede from it, in imitation of the terrestrial elements.¹⁷ By contrast, what Aristotle does is (in effect) to allow the stellar motions to become forced.

For there is a very real sense in which Aristotle is using a second—non-canonical—physics to account for his stellar kinematics. Each star is fixed in a rotating sphere—with star and sphere made of the same material (*On the Heavens*, II.7). In consequence, the star does not in the end acquire its motion from the canonical source—an individual innate tendency. Instead, the motion comes from the star's environment, the sphere of aether.

Aristotle is quite explicit that this is the case, for that is the message of *On the Heavens* II.8. The stars cannot be moving themselves individually, for then the motions would not be so perfectly coordinated. Instead, we must suppose that 'the circles (...) move, while the stars are at rest and move with the circles to which they are attached. Only on this supposition are we involved in no absurd consequence' (289b30-35). Presuming that the stars are individually spherical, he then adds two more arguments. Spheres are not well suited to progressive motion; and though they can spin well, only the sun seems to spin—and even that is just an optical illusion, associated with sunrise and sunset (*ibid.*, 290a5-290b10). Reversing this argument in II.11, he argues that the stars must be spherical because 'it has been shown that it is not in their nature to move themselves'. Accordingly, 'since nature does nothing without reason or in vain, clearly she will have given things which possess no movement a shape particularly unadapted to movement' (291b10-15).

36-60; M. Hoskin, 'Astronomy in Antiquity', *The Cambridge Illustrated History of Astronomy*, ed. M. Hoskin, Cambridge 1997, 22-47, esp. 43; E. Grant, *The Foundations of Modern Science in the Middle Ages*, Cambridge 1996, 107; O. Gingerich, *The Eye of Heaven: Ptolemy, Copernicus, Kepler*, New York 1993, 140; N. Jardine, 'The Significance of the Copernican Orbs', *Journal for the History of Astronomy* 13 (1982), 168-194, esp. 182-186.

¹⁷ Cf. Jardine, 'Significance of the Copernican Orbs', 170-171, 185.

These remarks of Aristotle's are puzzling, for they surely imply that much motion in the aether is forced. They unequivocally declare that the stars acquire their motion from an external source; and further, that the motion thus acquired is discordant with the spherical natures of the stars. That the tension detected in this discussion is real (and not some illusion generated by irrelevant hindsight) is indicated by Simplicius's dissatisfaction with this discussion of Aristotle's; and by Ptolemy, who gives the stars a spin, precisely because their natures seem to require it.¹⁸

Since the natural inclination of the stellar material is being overruled in the 'alternative' physics that Aristotle applies to the stellar motions here, the stellar motions should (it seems) not get classified as natural. But this is dramatically contrary to the canonical physics, where violence is restricted to the terrestrial region. The clash between the two principles is left unresolved, presumably because of the theological baggage attached to the insistence that aether only move naturally. To admit frankly that the stars move violently—and hence to free them from the problematical necessity to circle the Earth—would cost Aristotle too much elsewhere: his aether would be less equipped to take on the mantle of divinity.

The violence in the celestial region is, in any case, easy to overlook—because it is obscured. It seems that our attention is easily deflected from the precise motion of small portions of aether, or individual stars, by the fact that the celestial sphere as a whole is centred on the Earth: in consequence, its axis passes through the centre of the Earth. This (perhaps) makes the rotation of the *sphere* seem natural to peripatetics, and the anomaly gets disguised—despite the overt remarks of *On the Heavens* II.8 noted above.

It might however be suspected that Aristotle imagines the rotation of a sphere about an axis to be a species of the genus 'rotation about a centre', so does in fact count the motion of Polaris in his universe as motion 'about the Earth'. Some support is given to this possibility by the fact that the word Aristotle often uses in these contexts to refer to the centre about which the aether rotates, μέσον, is also used to refer to the celestial axis. An example of this occurs in *On the Heavens* II.14, where Aristotle summarises (prior to their rejection) some moving-Earth theories which have the Earth 'rolled and in motion about the pole as axis (περί τὸν πόλον μέσον)' (296a25-30).

My claim here would then be based on a misunderstanding: Aristotle (it would seem) did not assert that aether moves on Earth-centred circles. But if that were so, Aristotle's argument (*On the Heavens* II.3, 286a10-25, discussed above) that derived the existence of the Earth from the fact that each circular motion requires something stationary at its centre, would

¹⁸ Dicks, *Early Greek Astronomy*, 260-261, n.383. I have not been able to consult Simplicius, so have not checked Dicks's interpretation of him here.

require the Earth to be long and cylinder-like, bridging the universe from North to South Celestial Poles—for only then would something stationary be located at the centre of each stellar orbit. (We have already observed in n. 10 that it is not enough that there be matter stationary *somewhere* along the axis.) Such a cylinder would overlap with the 50 or so sub-stellar planetary spheres of Aristotle's universe; and many further cylinders, tilted at a variety of angles, would be required to place something material at the centre of every superlunary motion! This is obviously not what Aristotle has in mind: and we can thus tell that he does distinguish between motion about an axis and motion about a centre. He may—perhaps—overlook the distinction at times, but the reason for this neglect is not that he regards them as identical concepts.

So our interpretation of the Aristotelian tradition remains intact: its physics is strongly committed to the view that ethereal motions are centred on the Earth, despite such motions being grossly incompatible with the stellar appearances. I doubt however that Aristotelians were overly concerned about the evident problem of reconciliation here, and I know no discussion of this question in the literature, primary or secondary.

One reason for this neglect has already been suggested, the fact that Aristotelian tradition did not adequately reconcile the behaviour of a composite object with the behaviour of its component parts.¹⁹ Claims about the natural motion of *materials* (like aether), are fused with claims about the natural motion of *objects* (like the celestial sphere). Given (in the present case) that it seems beyond exception to describe the sphere as moving about the Earth, it becomes easy to transfer the description to the aether itself—without detecting that that the transferred description is false. Aristotle confirms this diagnosis, for he implies there is no problem here, simply declaring (in a couple of instances) that 'the natural movement of the whole and of its parts—of earth, for instance, as a whole and of a small clod—have one and the same direction' (*On the Heavens* I.3, II.14, quoting from 270a1-10). Roger Bacon later realised (in the thirteenth century) that this cannot be so, for a terrestrial macroscopic object (like a stick) cannot possibly undergo natural motion. Suppose indeed that it is falling in such a way as takes the centre of the stick towards the centre of the Earth. Then the ends of the stick

¹⁹ Cf. E. J. Dijksterhuis, *The Mechanization of the World Picture*, transl. C. Dikshoorn, Oxford 1961, 200-204 (on the *mixtio*-problem); G. Freudenthal, 'Clandestine Stoic Concepts in Mechanical Philosophy: the Problem of Electrical Attraction', *Renaissance and Revolution. Humanists, Scholars, Craftsmen and Natural Philosophers in Early Modern Europe*, ed. J. Field and F. James, Cambridge 1993, 161-171, esp. 164-172 (on peripatetic difficulties in accounting for cohesion); K. Hutchison, 'What Happened to Occult Qualities in the Scientific Revolution?', *Isis* 73 (1982), 233-253, esp. 240, n.20 (on properties of objects that transcend the properties of their component elements).

must be moving towards a point different from the centre of the Earth, so their motion must be forced.²⁰

We must also suspect that the discord here was suppressed by an ongoing tendency to think about three-dimensional problems via two-dimensional representations:²¹ if the axis of rotation of the celestial sphere is looked at end-on, it will seem that the rotation of each portion of the sphere is taking place about the centre of the universe. Descartes's vortices ended up in terrible trouble on analogous issues: Cartesian physics seemed to require that an object near the North Pole would fall horizontally rather than vertically.²²

So much then for the truth of the message promised at the opening of this note. Now let us consider its significance. That is far more difficult to assess, but our conclusion is at least paradoxical—in that historians routinely (and correctly) suggest that scholastic physics was one of the main supports for geostatic cosmology, and indeed, one of the principal obstacles to the acceptance of an alternative world-view in seventeenth-century Europe. In the end (this same suggestion continues) it was the widespread acceptance of Newtonian physics that enabled the dynamical objections to a moving Earth to be removed—after an equivocal Cartesian interlude. Yet given the claim established above, Newtonian physics turns out to be far more compatible with a stationary Earth than that of Aristotle—in either its original form, or in its early modern form: there seems to be no difference on this point.

At first sight, it is true, the Newtonianism that finally supplanted Aristotelianism seems equally incompatible with a stationary Earth, and for much the same reason: the diurnal motion of stars apparently requires 'too incongruous' a system of forces 'hardly to be reconciled with any physical theory', as Newton himself put it,²³ implying that it is the motion of the Earth

²⁰ Roger Bacon, *The Opus majus of Roger Bacon*, transl. R. B. Burke, 2 vols., Philadelphia 1928, I, 188-189.

²¹ Cf. J. Field, 'Mathematics and the Craft of Painting: Piero della Francesco and Perspective', *Renaissance and Revolution*, 73-95, esp. 74.

²² H. J. M. Bos, 'Huygens', *Dictionary of Scientific Biography*, VI, ed. C. C. Gillispie, New York 1972, 597-613, esp. 610; E. Aiton, *The Vortex Theory of Planetary Motions*, London 1972, 77, 153, 172ff.; R. Westfall, *The Construction of Modern Science: Mechanisms and Mechanics*, Cambridge 1971, 36 (who cites this as typical of the problems especially associated with devising anti-Aristotelian explanations).

²³ Newton, *System of the world* [an early 1684-5 version of Book III of the *Principia*], 553-4 in I. Newton, *Mathematical Principles of Natural Philosophy and his System of the World*, transl. (in part) A. Motte [1729], revised F. Cajori, Cambridge 1934. NB: the *System* is perhaps not transl. by Motte: I. B. Cohen, 'Newton's System of the World: some Textual and Bibliographical Notes', *Physis* 11 (1969), 152-66, on 157. Cohen also notes that this Cajori version of the *System* is not deemed a consistently reliable guide to Newton's personal thoughts. Cohen's analysis here implies however that there are no significant differences between the Newtonian Latin, and the 1728 English version of this argument against orbiting stars. (Nor is the exact extent to which Newton personally accepted the precise details important to the present discussion.) Though the argument here obviously applies to the planets

(rather than that of the stars) which causes the diurnal appearances.

For Newton correctly points out that if the Earth is stationary in absolute space, and Newtonian mechanics is accepted, then a force has to be acting on each star, directed to the centre of its orbit. But there is no matter evident on the cosmic axis, so (he seems to imply) there can be no plausible cause for this force beyond an erratic will of God. Furthermore, if the forces on different stars are compared, the forces can be seen to *increase* with the distance of a star from the celestial axis—because the angular velocity of rotation is the same for all stars. Stars near the celestial poles, for example, will be moving on very small circles, so will be accelerating centripetally at a far smaller rate than stars near the equator. From this, worse follows: the force on the one star cannot itself be constant over time, for precession causes a slow change in the distance of each star from the axis.

This argument certainly supports the widely held historical notion that it was Newtonian physics which definitively refuted the cosmologies competing with Copernican astronomy since the middle of the sixteenth century: compelling evidence for the motion of the Earth was in short supply until the arrival of inertial dynamics, it seems, but it was plentiful thereafter.²⁴ Yet we have already noted that the diurnal kinematics are quite incompatible with scholastic cosmology—so difficulty in reconciling a stationary Earth with the stellar appearances is not at all a novel consequence of Newtonian mechanics.

Nor does Newton's analysis exclude every plausible method of accommodating a stationary Earth. For if we follow the Aristotelians here, and allow the stars to be embedded in a transparent solid, the substance of Newton's objection evaporates. Indeed, the very forces that Newton declares to be 'incongruous' are present in every rotating solid, and act indeed on the 'small clods' that make up the Newtonian Earth. So Newton's argument here clearly depends on a premise very similar to the assertion with which he opens his close analysis of planetary motion: 'the matter of the heavens is fluid'. Through this, it depends critically on his reasons for insisting that no solid spheres exist—the behaviour of comets (*Principia*, 549-50).

To the great majority of Newton's contemporaries, such fluidity of the heavens was unproblematic, for they were already Copernicans and their beliefs had already moved in the direction of an infinite universe of

as well, it must be noted that the *System* presents quite separate arguments in favour of a Copernican treatment of the slight differences between planetary and stellar motions (e.g. Newton, *Mathematical Principles*, 572-5). These arguments generate no paradox of the type discussed below, so are not in any way dealt with in the present paper.

²⁴ E.g.: Kuhn, *Copernican Revolution*, 224-228, 261; K. Hutchison, 'Sunspots, Galileo, and the Orbit of the Earth', *Isis* 81 (1990), 68-74, esp. 71.

disconnected stars.²⁵ Tycho's work had indeed eliminated Aristotle's planetary spheres, but it did not directly impugn the solidity of the stellar sphere.²⁶ So Newton overestimates the strength of his argument here. Kepler for one had felt able to retain a solid sphere for the stars—as an essential component of his 'trinitarian' (solar-planetary-stellar) universe—despite insisting that the *planetary* environment is 'limpid' and yielding.²⁷

As regards heat: the sun is the fireplace of the world; the [planetary] globes in the intermediate space warm themselves at this fireplace, and the sphere of the fixed stars keeps the heat from flowing out, like a wall of the world, or a skin or garment (...) The sun is fire (...) or a red-hot stone (...) and the sphere of the fixed stars is ice, or a crystalline sphere, comparatively speaking.

Kepler's opinion here was certainly a minority one. Yet the reasons that others abandoned the stellar sphere were very mixed. Some (perhaps the main ones, according to Donahue²⁸) were dynamical, new opinions about the way God generates the stellar motions—but they were quite distinct from Newton's dynamics. In other words, rotation of the stars remains dynamically possible in a Newtonian universe. Once again, a 'rational' argument for Copernicanism is shown to be remarkably weak,²⁹ and we cannot reject the stationary Earth by appeal to the stellar appearances! Dynamical arguments for Copernicanism are critically dependent on appeal to the planets.

²⁵ Donahue, *Dissolution*, 13.

²⁶ T. Brahe, *De mundi aetherei recentioribus phaenomenis* [Recent Phaenomena], 1588, excerpt from c.8., transl. M. Boas and A. R. Hall, 'Tycho Brahe's System of the World', *Occasional Notes of the Royal Astronomical Society* 3 (1959), 253-263, on 259-260.

²⁷ J. Kepler, *Epitome of Copernican astronomy*, [1620], books 4 and 5, transl. C. G. Wallis, *Great Books of the Western World*, Chicago 1952, XVI, 843-1004, esp. 853-857, quoting from 855. J. L. E. Dreyer, *A History of Astronomy from Thales to Kepler*, New York 1953, 371, 410-411 (whose claims however are only partially documented).

²⁸ Donahue, *Dissolution*, 203-218, esp. 217.

²⁹ Cf. Hutchison, 'Sunspots'.

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K.V. SNEDEGAR

THE WORKS AND DAYS OF SIMON BREDON,
A FOURTEENTH-CENTURY ASTRONOMER AND PHYSICIAN

John North once told me that Simon Bredon was a difficult character to pin down. At first blush he appeared, next to Richard of Wallingford, to be one of the great mathematical astronomers of fourteenth-century England. Yet as one probed Bredon's academic life and works they seemed to retreat like a shadow from the daylight of historical research. Nonetheless, since the late Middle Ages the name 'Bredon' has been replicated innumerable, attached to colophons of logical and mathematical treatises, inscribed in library catalogues, included on lists of profound medieval Oxonians. It was as if long after the demise of the man the bells of antiquarian tradition continued to sound, and amplify, his name. One might echo the words of A. E. Housman in *Bredon Hill*: 'Oh, noisy bells, be dumb; I hear you, and will come.' In this article of gratitude for my former thesis supervisor I hope to confound the bells somewhat by interrogating the silent witnesses to Bredon's life: texts (main and marginal) in codices from his personal library, and the text of his singularly informative last will and testament.

Like that of so many medieval individuals, more is known of Simon Bredon's end than of his beginning. He drafted his will at Battle Abbey on 12 October 1368; it was proved in May 1372.¹ Not surprisingly, no documentary evidence exists for his early life. One trace of his family comes from a record of him borrowing a horse to attend the 1350 funeral of a certain Richard Bredon, who was perhaps a brother.² In his will Bredon also named three nephews: John Belton, who was both *nepos* and *consanguineus meus*, and Alan de Kelsale and John Staurgeon, each designated *nepos*. To Staurgeon he bequeathed his lands at Belton, Epworth, and elsewhere on the Isle of Axholme, west of Scunthorpe, Lincolnshire. These northeastern family ties, together with the patronage Bredon would receive from archbishop Islip, himself from the Lincoln diocese, suggest that Bredon hailed from that area. At all events, he could not have been born much before 1310.

¹ Bredon's will is printed in F. M. Powicke, *The Medieval Books of Merton College*, Oxford 1931, 82-86.

² MCR (Merton College Record) 3712. See also, E. Clark Lowry, 'The Administration of the Estates of Merton College in the Fourteenth Century', Oxford D.Phil. thesis 1933, 254.

Oxford scholar, 1330-1348

On the strength of Bredon's gift of three books to Balliol College, C. H. Talbot inferred that Bredon entered that establishment when he first came up to Oxford in the late 1320s. In doing so, Bredon was following Thomas Bradwardine, Adam Pipewell, and John Severley, near contemporaries resident at Balliol previous to their Merton College fellowships.³ Despite that, only after Simon became a fellow of Merton would there be any explicit record of his activities.⁴ Between 1330 and 1341 he is named in Merton College records no fewer than seventeen times. In addition to his studies Bredon was active in college and university governance. Already in 1333 he is to be found pleading the University's case at the Papal Curia regarding the archdeacon of Oxford's jurisdiction over the community of scholars. Thereafter he became one of the Proctors of the University (either in 1337-38 or 1338-39), and a keeper of the newly created Langton Chest. At college meetings, or scrutinies, Bredon argued for improved access to library holdings. Also during the late 1330s he served as a Merton *procurator*, conducting administrative visits to college estates such as the manor of Cuxham.⁵

Bredon entered Merton College at the zenith of its fourteenth-century academic preeminence.⁶ Among its fellowship in the first half of the century were Walter Burley, John Gaddesden, John Maudith, Thomas Buckingham, Thomas Bradwardine, Richard Billingham, William Heytesbury, John Dumbleton, John Ashenden, William Rede, Richard Swineshead—a veritable who's who of scholarship of the age. Yet what is often lost in the mere concatenation of names is that a dynamic of collegial relationships in the shape of friendships, rivalries, collaborations, disputations, and so on, must have energized individual fellows. There are signs that Bredon experienced constructive relationships, even life-long friendships, with

³ C. H. Talbot, 'Simon Bredon (c.1300-1372) physician, mathematician and astronomer', *British Journal for the History of Science* 1 (1962), 19. Balliol received three volumes from Bredon: Avicenna's *Canon* 'scriptum de Ragg' (now Balliol MS 89), Boethius, *De arte metrica*, and Cicero, *Rethorica*. R. A. B. Mynors, *Catalogue of the Manuscripts of Balliol College, Oxford*, Oxford 1963, xiii-xiv.

⁴ A. B. Emden, *A Biographical Register of the University of Oxford to A.D. 1500* (hereafter abbreviated BRUO), Oxford 1957, i, 257-258. I have consulted the annotated BRUO at the Selden End of Duke Humfrey's Library in the Bodleian. Unless otherwise indicated, all biographical information concerning Bredon originates from this source. A derivative if often cited biographical account is to be found in C. H. Talbot and E. A. Hammond, *Medical Practitioners of Medieval England. A Biographical Register*, London 1965, 320-322.

⁵ P. D. A. Harvey, *Manorial records of Cuxham 1200-1359*, London 1976, 760.

⁶ A fair treatment of the intellectual milieu of fourteenth-century Merton College is in G. H. Martin and J. R. L. Highfield, *A History of Merton College, Oxford*, Oxford 1997, esp. chapters 3-5.

several colleagues. The illustrious old member John Gaddesden may have inspired Bredon to turn to medicine (for more on this, see below), but the mathematical works of Thomas Bradwardine surely made a deeper impression on the young Bredon. Bradwardine's mathematical productions included textbooks on arithmetic and geometry, and culminated in 1328 with his ground breaking *Tractatus de proportionibus*. Like Bradwardine, who was about five years his senior, Bredon became a specialist in the mathematical portion of the arts curriculum. Bradwardine's ancillary interest in astronomy may also have steered Bredon in that direction. The logician William Heytesbury, a Merton fellow in the 1330s, became a trusted friend. Heytesbury and Bredon were together at Merton for at least six years, during which time Heytesbury's philosophical scholarship influenced Bredon's astronomy. The two men kept in touch after their Oxford years; during the 1360s both were canons in the collegiate church at Wingham, Kent. Bredon's will enshrines their long friendship; it named Heytesbury chief executor, with full authority to dispose of all books, monies and possessions not specifically granted to others.⁷

Bredon's association with three junior colleagues involved in the *scientia astrorum*—William Rede, John Ashenden, and William Merle—may be characterized as mentorship. A Merton fellow by 1344, Rede had come up to Oxford in the late 1330s.⁸ The evidence of Bredon's mentor-protégé relationship with Rede is compelling if circumstantial. Rede drafted a table of solar positions for the years 1341-1344, at a time when Bredon was studying Ptolemy's theory of solar motion (*Almagest*, Book III). Apparently, Rede was willing to undertake the drudgery of arithmetical calculation; he made his name as the compiler of Alfonsine-style astronomical tables of planetary positions, epoch 1340, for the Oxford meridian. Although theoretically trivial, the manual computation of some 40,000 digits within the tables represents incredible effort on Rede's part.⁹ As we shall see, the senior scholar concerned himself rather with determining fundamental astronomical parameters that lay behind the drafting of such tables. A second junior colleague was John Ashenden (Merton fellow by 1336). When Bredon resigned as Merton *procurator* he did so in favor of Ashenden, whom he called *dilectus magister*.¹⁰ Ashenden's scholarly activity focused

⁷ Powicke, *Medieval Books*, 85-86. BRUO, ii, 927-928.

⁸ Like Heytesbury, Rede was also a canon of Wingham in the 1360s; in Bredon's will he was designated to receive Bredon's smaller astrolabe. BRUO, iii, 1556-1560.

⁹ J. D. North, 'The Alfonsine Tables in England', in *PRISMATA. Festschrift für Willy Hartner*, ed. Y. Maeyama and W. Salter, Hildesheim 1977, 290. Rede's 1341-1344 solar tables are preserved in MS Digby 176, fol. 71-72v. The table of contents of that manuscript describes the work as *Almanak solis pro quattuor annis per W. Reed anno Christi 1337 calculata et scripta*.

¹⁰ MCR 437, dated to November 1340.

on a distillation of astrological literature regarding celestial influences over global affairs; the result was a massive compilation entitled *Summa judicialis de accidentibus mundi*. He also made a series of predictions based on lunar eclipses and planetary conjunctions occurring between 1345 and 1365.¹¹ Bredon provided Ashenden with texts to study, the most significant being his own recension of Ptolemy's *Quadripartitum* (for which, see below). Although never a fellow of Merton, William Merle, a Lincolnshire parish priest who received licence to study at Oxford between 1337 and 1341, and again in 1347, also belonged to the Bredon circle. Merle specialized in meteorology, keeping a weather diary for the period 1337-1344 (a unique effort in fourteenth-century England), and investigating both Aristotelian natural philosophy and folk wisdom in search of a means to forecast the weather. Merle's weather diary passed into Rede's possession. Merle is also recorded as having borrowed, but never having returned, a volume from Bredon's personal library.¹²

Bredon experienced a major career transition in the 1340s. In the company of Rede, Ashenden and Merle, he was steeped in astronomical and astrological scholarship at the beginning of the decade; yet he had definitely completed his regency in arts before 1340. It was now time for him to proceed either to a higher faculty within the university or to a non-academic career. Significantly, Merton College records distinguish Bredon as a fellow for the last time in 1341. One reason for him to have vacated his fellowship would have been his entry into the faculty of medicine since Archbishop Peckham's injunctions explicitly forbade medical study at Merton.¹³ Also consistent with this period of Bredon's life is the fact that the course toward inception in medicine normally lasted six years; there is at least no positive reason to think that he left Oxford before his first Church appointment in May 1348. During the intervening years he presumably rented lodgings in Oxford from Oseney Abbey, because in his will he gave forty shillings to the Austin Canons of Oseney *ad redimendum, si in aliquo deliqui morando in domibus eorum*. It is not at all clear how Bredon, without fellowship or benefice, supported himself at this time. A one-hundred shilling 'student

¹¹ For this Rede executed many of the necessary calculations; see my 'John Ashenden and the Scientia Astrorum Mertonensis', Oxford D.Phil. thesis 1988, 47, 265-266. The incipit to the canons of Rede's tables makes plain the astrological application of astronomical calculation: *Volentibus pronosticare futuros effectus planetarum in istis inferioribus (...)*

¹² K. V. Snedegar, 'Between Scholasticism and Folk Wisdom: The Weather Lore of William Merle', *Southern African Journal of Medieval and Renaissance Studies* 5 (1997), 29-36.

¹³ For the consequences of Peckham's visitation, see Martin and Highfield, *History of Merton College*, 50-51. Merton men such as John Gaddesden and John Maudith became physicians in any case, but it is probable that they too entered the Faculty of Medicine only after resigning their fellowships.

loan' from Merton in 1345 must have helped immensely.¹⁴

The choice of medicine, rather than law or theology, must have been a fairly straightforward one. After all, medieval medical theory allowed for celestial influence on human health. Bredon could retain his enthusiasm for astronomy while pursuing a new field, one from which he would earn a living. Signs are that he engaged medicine with his usual zeal. Neil Ker identified an alphabetical herbal with copious marginalia and an index by Bredon.¹⁵ No doubt as student exercises he similarly glossed the *Passionarium* of Gariopontus (Merton College MS C.2.I) and indexed the Constantinus Africanus translation of the *Pantegni* (Merton MS H.3.5).

In all likelihood Bredon completed his medical training before the onset of the Black Death. There is no way of knowing whether he was a recognized practitioner during the plague years, but by 1355 he was styling himself *doctor medicinae* and counted the wealthiest aristocrat in the realm among his patients.

The canon of Bredon's writings

In terms of intellectual history the problem with Simon Bredon lies in establishing the canon of his writings. On the testimony of early antiquarians and bibliographers, principally Bale and Tanner, Emden credited Bredon with fourteen scholarly works: (1) *Questiones in X libros Ethicorum*, (2) *Expositio arismetrice Boicii*, (3) *Commentum super aliquas demonstrationes Almagesti*, (4) *Tabulae cordarum*, (5) *Calculationes cordarum*, (6) *De proportionibus*, (7) *Expositio in computum ecclesiasticum Rob^u Grostede*, (8) *Theorica planetarum*, (9) *Trifolium de re medica*, (10) *Nomina instrumentorum astrolabii*, (11) *Conclusiones quinque de numero quadrato*, with *Notae breves mathematicae atque astronomicae*, (12) *Super introductorio Alcabitii*, (13) *Astronomia calculatoria*, and (14) *Astronomia judiciaria*. In addition to these (and generally in library catalogues) a mathematical treatise entitled *De minutiis*, a *Commentarius in opus quoddam logicale*, a commentary on the *computus* of Alexander of Villa Dei, and an important Middle English text, the *Equatorie of the Planetis*, have been ascribed to Bredon.

Several of the attributions are authentic; some cannot be verified; some are plainly mistaken. Derek Price convincingly argued four decades ago that Bredon did not compose the *Equatorie of the Planetis*; however, attempts to positively identify the author—some scholars have hoped for Chaucer—

¹⁴ MCR 3678.

¹⁵ Oxford, Pembroke College, MS 12, fol. 1-66v. N. R. Ker, *Medieval Manuscripts in British Libraries*, Oxford 1983, iii, 682-683.

have proved inconclusive.¹⁶ Similarly, the *Questiones in X libros Ethicorum Aristotelis* and *Commentarius in opus quoddam logicale*, each preserved in a single manuscript, should not be connected with Bredon. No modern scholar has analyzed the content of either manuscript, but the *Questiones* may well be the work of Walter Burley and the *Commentarius* of Jean Buridan.¹⁷ It is also exceedingly unlikely that Bredon produced a commentary on the astrological treatise of Alchabitius; he was, however, responsible for a new Latin recension of Ptolemy's *Quadripartitum* (to be equated with the *Astronomia iudiciaria*?).¹⁸ The commentary on the computus of Grosseteste and the *De minutiis* are mere disembodied titles. Also lost or unidentified are the *Tabulae cordarum* and *Calculationes cordarum*, but these almost certainly pertained to Bredon's *Commentum super aliquas demonstrationes Almagesti*.

Of surviving texts, the *Nomina instrumentorum astrolabii* and the commentary on the *computus* of Alexander of Villa Dei had the Bredon name attached to them by librarians no earlier than the sixteenth century. It is more likely than not that they are the works of someone other than Bredon. Preserved in two manuscripts, the *Tabula declinationis Solis* are essentially William Rede's solar tables; credit should go to Rede for them. Altogether then, only six extant works may be confidently assigned to Bredon:

Title	Probable dates
1 <i>Expositio arismetrice Boicii.</i>	Early 1330s.
2 <i>Notae breves mathematicae atque astronomicae</i>	Mid 1330s.
3 <i>Theorica planetarum.</i>	Mid 1330s.
4 <i>Quadripartitum.</i>	Late 1330s; before 1347.
5 <i>Commentum super aliquas demonstrationes Almagesti.</i>	Circa 1340.
6 <i>Trifolium de re medica</i>	Mid 1340s.

¹⁶ D. J. Price, *The Equatorie of the Planetis. Edited from Peterhouse MS. 71.1; with a linguistic analysis by R. M. Wilson*, Cambridge 1955. K. A. Rand Schmidt, *The authorship of the Equatorie of the Planetis*, Woodbridge 1993. J. D. North considers it a 'moral certainty' that the *Equatorie* belongs to Chaucer. *Chaucer's Universe*, Oxford 1988, 181.

¹⁷ 'The work on logic ascribed to him by Bale and stated by Bale to be in Magdalen Coll. Library may be the same as Magdalen Coll. library MS 88, and anonymous work of which H. O. Coxe suggested Jo. Buridan as author.' BRUCO, i, 258. The questions on Aristotle's *Ethics* have probably avoided scrutiny on account of their location: Vienna, Bibliothek Monast. B.V.M. ad Scotos, MS 278. This text could be a recension of Burley's commentary on the *Ethics*, which circulated widely on the Continent. J. A. Weisheipl, 'Repertorium Mertonense', *Mediaeval Studies* 31 (1969), 205-206.

¹⁸ Ashenden emphasizes the authority of Ptolemy's *Quadripartitum* in his *Summa judicialis de accidentibus mundi*, very much to the disadvantage of the *Introductorius* of Alchabitius; he was clearly dependent on the texts of the *Quadripartitum* which Bredon collected (see below).

These items form a skeletal outline of Bredon's thinking life: an initial period of lecturing *pro forma* in the quadrivium¹⁹; his specialization in the *scientia astrorum*, culminating in the *Almagest* commentary; and his final choice of medicine as a career path. Attaching some meat to these bones—the historian's *habeas corpus*—now follows.

A Boethian mathematician

A commentary on the arithmetic of Boethius, *Expositio arismetrice Boicii*, is the most substantial mathematical composition attributable to Bredon. Comprising two books of twelve and fifteen chapters respectively, the work is an instructional guide for one of the standard texts in the quadrivial curriculum. As such it adheres closely to the structure of the text as well as to Boethian number theory. Book one is mostly taken up with the difference between even and odd numbers. Book two addresses geometrical numbers, with an emphasis on squares. Operations involving fractions are also discussed. Boethian proportionality must have been a point of departure for Bradwardine's analysis of motion in his *De proportionibus*. In the *Expositio*, however, Bredon was simply focused on providing the student a competent abstract. As a pedagogical effort it was a modest success, as no fewer than seventeen manuscript copies attest. The *Expositio* continued to be utilized in Oxford well into the fifteenth century; one of later English copies is in the hand of the famous composer John Dunstaple.²⁰ It also reached such places as Paris and Salamanca. Wrongly assigning the tract to Bradwardine, Pedro Cirvelo issued the 1495 editio princeps under the title *Arithmetica speculativa*—one of two instances of a misattribution to Bredon's disadvantage.

Bredon's other purely mathematical remains are rather slight and were doubtless intended for classroom use. A little tract entitled *Conclusiones quinque de numero quadrato* is located in MS Digby 178. Here Bredon has penned five conclusions on square numbers including a criticism of the *De perspectiva* of Vitellio.²¹ The *Conclusiones*, however, appear to be only a somewhat more organized section in a heterogeneous mass of mathematical notes (traditionally referenced as *Notae breves mathematicae atque*

¹⁹ Namely, arithmetic, geometry, music, and astronomy. Geometry is conspicuously absent in Bredon's pedagogical writings. Perhaps he could not improve upon Bradwardine's lucid *Geometria speculativa*. See G. Molland, *Thomas Bradwardine, Geometria Speculativa. Latin Text and English Translation with an Introduction and a Commentary*, Stuttgart 1989.

²⁰ For Dunstaple, *musici et astrorum conscius*, see M. Dent, *Dunstaple*, London 1981, 1-9.

²¹ Talbot, 'Simon Bredon', 23. The *Conclusiones* conclude with what seems to be an autograph at fol. 13r: 'ego Simon de Bredoun'.

astronomicae, see Appendix B). Among other things Bredon's scribbblings reveal an interest in music theory; they contain extracts from *De musica* of Boethius and a graph of a musical scale. These manifest a conservative *ars antiqua* approach to music within the Oxford curriculum.²² What presumably was another of Bredon's pedagogical works is attested to in a catalogue (dating to about the year 1380) of John Erghom's personal library. An Austin canon of York with a penchant for collecting technical treatises, Erghom owned a copy of Bredon's *Expositio* but also a separate tract on fractions listed as *Bridon de minutiis*. This may have something to do with a *De proportionibus* which Bale found in a Merton College manuscript and attributed to Bredon; nonetheless, the work cannot now be positively identified.²³

Bredon's Theorica planetarum

As a lecturer in the quadrivial subjects Bredon naturally would have taught foundational texts of astronomy such as the *Sphere* of Sacrobosco and the *Theorica planetarum*. It is no surprise, then, that a fourteenth-century *Theorica* of English provenance should be attributed to him. However, manuscript colophons, tables of contents, and library catalogues variously ascribe this work to Campanus of Novarra, Gerard of Sabbioneta, and a certain Walter Brytte who possibly was a fellow of Merton toward the end of the century. Olaf Pedersen has written with great insight on Walter Brytte and his association with this *Theorica*.²⁴ Pedersen identified eight manuscripts, of which three name Brytte; one (MS Digby 48) bears the title *Theorica planetarum Bredon* with these accompanying memorial verses:

Qui cupis astrorum septem bene scire sophiam
Hunc lege tractatum qui continet astronomiam
Namque domus Merton hoc fecerat arte potitus
Astronomus Bredon consocius atque peritus
O Deus astripotens animi Bredon miserere
Cum sanctis statuas qui dicunt kyrie khere.

Pedersen dismissed the ascription for two reasons. Bredon 'seems in general

²² See F. Ll. Harrison, 'Music at Oxford before 1500', in *The History of the University of Oxford. Vol. II: Late Medieval Oxford*, eds. J. I. Catto and R. Evans, Oxford 1992, 353-356. Bredon's notes *extracta de musica Boicii* are in MS Harley 625, fol. 175; his *De scala musica*, MS Digby 178, fol. 14r. Bredon owned a copy of the *De musica* which was designated to go to Balliol College upon his death; it has since been lost.

²³ *Corpus of British Medieval Library Catalogues: The Friars Libraries*, ed. K. W. Humphreys, London 1990, 154.

²⁴ O. Pedersen, 'The Problem of Walter Brytte and Merton Astronomy', *Archives Internationales d'Histoire des Sciences* 36 (1986), 227-248.

to have worked on a higher level than the *Theorica*, being familiar with and commenting on the *Almagest*.²⁵ Also, the title and verses in MS Digby 48 are written in a much later hand than that which copied the text itself. More or less by denying Bredon's authorship, Pedersen advanced the case for Brytte's.

I believe the preponderance of the evidence, including unique features of the *Theorica*, supports an attribution to Bredon. First of all, the argument that Bredon 'worked on a higher level' is a weak one. The history of science is replete with advanced researchers who also wrote elementary textbooks; and we have already seen that Bredon produced an elementary arithmetical text. As for the date of the memorial verses, Pedersen was unaware that they appear in Corpus Christi College MS 132 in the same fifteenth-century hand that rendered the text. Admittedly, only two of the thirteen *Theorica* manuscripts now known to exist (see Appendix B) name Bredon, and none of the thirteen dates to before circa 1390. Yet few of the manuscript copies of Bredon's other authentic works have his name on them either; most of these are fifteenth-century copies, too. The sole fragment of his *Trifolium* is a late copy.

Pedersen was undeniably correct in stating that fair evidence exists for connecting the *Theorica* with a Merton fellow. I agree with him that a key source is John Holbrook's astronomical miscellany, the so-called *Codex Holbrookianus*.²⁵ Largely devoted to the astronomical tables drafted by Merton fellows John Maudith and William Rede, and to Holbrook's revision of their work, the codex also contains a table of solar declinations attributed to Bredon. That the *Theorica* is to be found in this collection suggests that it pertains to the Merton school. It may also be inferred from contents of the *Theorica* that the treatise belongs to the second quarter of the fourteenth century, the period of the reception of the Alfonsine Tables in England and the golden age of the Merton school. Pedersen observes that the 'Old *Theorica*' was confused in its treatment of astronomical tables, referencing works of mythical astronomers such as Nimrod and Hermes. The Bredon/Brytte *Theorica* refers only to the Alfonsine Tables; unlike the *Old Theorica* it consistently uses sexagesimal numbers after the fashion established by the Alfonsine Tables; and the values for the mean daily motions of planets given in the *Theorica* correspond with Alfonsine mean motions.²⁶ According to J. D. North the Alfonsine Tables only became widely known in England in the 1330s. Richard of Wallingford, for instance,

²⁵ British Library, MS Egerton 889. Holbrook was Master of Peterhouse, Cambridge, from 1418 to 1431. In 1426 he presented some of his books, including this manuscript, to his college.

²⁶ Pedersen, 'The Problem of Walter Brytte', 243-244.

made no use of them in his works dating to 1327 but apparently learned of them before his death in 1336.²⁷ Another feature of the *Theorica* which intrigued Pedersen was the *uniformiter/diformiter* terminology for motion indicative of the Mertonian kinematical theories being articulated in the 1330s. Even if such terminology existed previously it became well established with William Heytesbury's innovative *Regulae solvendi sophismata* of 1335.²⁸ Part three of the *Regulae* focused on the analysis of uniform motion (*motus uniformis*), acceleration (*motus difformis*), uniform and non-uniform acceleration (*motus uniformiter difformis*; *diformiter difformis*), and the like. The author of the *Theorica* was interested in uniform circular motion, that is to say a point on a circle moving through equal angles in equal times, while accepting that this implied non-uniform motion along the radius joining that point with the center of the circle. Although the *Theorica* remarks that astronomers and physicists differ on the paradox of circular motion, the discussion is strongly reminiscent of that in Heytesbury's *Regulae*.²⁹

Would it not have been natural for a thoughtful regent master, Simon Bredon, actively engaged in lecturing and writing on the quadrivium in the mid-1330s, to have revised the *Old Theorica* in the fresh light of Alfonsine astronomy and the natural philosophy of a close personal friend, Heytesbury? Natural and highly probable. The chief question about the *Theorica* does not concern its authorship, then, but how Brytte's name become attached to it more than a half century after its composition. It is not difficult to imagine. Originally Bredon may have used the *Theorica* in his personal lecturing alone; even years after his death it might have circulated no further than his immediate students and colleagues (as had been the case with his *Quadripartitum* recension and *Almagest* commentary). Brytte's contribution must have been in recovering an underutilized textbook. The memorial verses are a tribute to the author by an enthusiastic reader two or three generations removed. Through confusion between the similar names

²⁷ North, 'The Alfonsine Tables in England', 273.

²⁸ For a review of Heytesbury's *Regulae* in the general context of Mertonian natural philosophy, see J. D. North, 'Natural Philosophy in Late Medieval Oxford', in *The History of the University of Oxford*, Vol. II, 85-88. See also W. J. Courtenay *Schools and Scholars in Fourteenth-Century England*, Princeton 1987, 243-247. Courtenay believes that much Heytesbury's work was derivative from that of Thomas Bradwardine and Richard Kilvington.

²⁹ 'Nota secundo quod dupliciter loquuntur philosophi de uniformitate et difformitate motus, uno modo dicunt naturales phisici, et alio modo astronomi. Naturales enim phisici dicunt, quod si aliquid movetur in temporibus equalibus pertranseundo equalia spacia, tunc dicitur illud uniformiter moveri. Sed astronomi dicunt, quod illud uniformiter movetur, quod in equalibus temporibus causat super aliquo centro fixo equales angulos, aut quod in temporibus equalibus equales arcus rescatur de circumferencia alicuius circuli'. MS Digby 15, fol. 60r, quoted in Pedersen, 'The Problem of Walter Brytte', 245.

Bredon and Brytte, and by the rapid copying of texts, the matter of authorship billowed into a bibliographical cloud of unknowing.

Interpreting, demonstrating, observing the Ptolemaic universe

By the late 1330s Bredon was devoting his energy to the most authoritative texts in the medieval *scientia astrorum*, namely those associated with Claudius Ptolemy. It is not too much to claim that Bredon had an intentional, structured Ptolemaic program. After all, one of the texts that attracted his attention was entitled *Introductorium ad artem spericam*. Considered Ptolemaic by the likes of Albertus Magnus and Roger Bacon, the elementary treatise actually belongs to Geminus of Rhodes. A fourteenth-century manuscript with significant Mertonian content, Bibliothèque Nationale Paris cod.lat. 16198, includes the *Introductorium*. Even if Bredon were not personally connected with that volume, *Introductorium* excerpts are to be found in other Bredon codices.³⁰

Bredon closely studied Ptolemy's astrological handbook, the *Quadripartitum*, collecting the two Latin renditions available at Oxford: the translation by Aegidius de Tebaldis from an Arabic version, accompanied by the commentary of 'Ali b. Ridwan, and an anonymous thirteenth-century translation made directly from the Greek.³¹ While there is no reason to believe that Bredon had the linguistic competence to attempt a new translation, he apparently endeavored to improve upon the existing texts as he drafted his own Latin recension, mixing and matching readings from the two translations and making some independent amendments. As far as I have been able to tell, Bredon's only substantive change was to clarify the terminology of zodiacal triplicities. Aegidius applied the words *triangulus* and *triplicitas* to refer to these groups of three constellations; the anonymous translator rendered *triplicitas*, *trigonalitas*, and *trigonum*. Bredon utilized *triplicitas* exclusively. Nonetheless, the Bredon *Quadripartitum* underlies much of John Ashenden's *Summa judicialis* which borrows wholesale from the elder scholar's textual work.³²

Around the year 1340 Bredon set out to compose an exposition on Ptolemy's *Almagest*.³³ The *Editio Bredon de Almagest*, as it was labeled in

³⁰ MSS Digby 168, fol. 118r, 120v; Digby 178, fol. 14r; Harley 625, fol. I, 1-6v. G. Aujac discusses the medieval reception of the Greek text in Geminus. *Introduction aux Phenomenes*, Paris 1975, civ-cviii.

³¹ MS Digby 179. See F. J. Carmody, *Arabic Astronomical and Astrological Sciences in Latin Translation*, Berkeley 1956, 19.

³² Snedegar, 'John Ashenden', 103-107.

³³ I believe a reference in John Ashenden's *Tractatus de significatione conjunctionis Saturni et Martis in Cancro* to Bredon calculating the movement of the eighth sphere 'circa annum Christi 1340' is to Bredon's *Commentum* and activities related to *Almagest* Book III.

Simon's copy (MS Digby 168), was clearly intended as a definitive treatment of the fundamental text of ancient Greek astronomy. With the purpose of mastering the spherical trigonometry of the *Almagest* Bredon intensively studied the works of Euclid, Menelaos, Theodosius, Thabit ibn Qurra, Jabir ibn Aflah and Richard of Wallingford.³⁴ It is as if Bredon had taken to heart Ibn Qurra's *De hiis que indigent antequam legatur Almagesti*. Unlike his recension of the *Quadripartitum*, the *Almagest* commentary does not nit-pick about textual issues in Gerard of Cremona's Latin translation; instead it is principally devoted to theorems and demonstrations. Hence in the fifteenth-century copy which John Dee later possessed the work bears the title *Commentum super aliquas demonstrationes Almagesti*. The four extant manuscripts of the commentary present a fragmentary work (See Appendix B). In Digby 168 Books I and II begin imperfectly on account of missing leaves (the old foliation would have been fol. 24-26 and 29-30). The Digby 178 text makes up for some of the loss in Book I with ten earlier propositions. Even so, it commences at *Almagest* I.12 with instructions on how to make an instrument to measure the obliquity of the ecliptic: *Instrumentum componere per quod maxima declinatio ecliptice equinoctiali certitudinaliter poterit mensurari*. As the sections immediately preceding would have been a table of chords subtended by arcs of a circle (I.11) and the method of deriving chord lengths (I.10), and as Bredon has been credited with *tabulae cordarum* and *Calculationes cordarum*, it is reasonable to assume that he did in fact incorporate these into his treatise, but that they have been lost or remain unidentified.³⁵ The manuscripts preserve Bredon's coverage of Books II and III much more fully; and Book III regarding the apparent motion of the Sun is of particular interest.

The competent review of the equivalence of the eccentric and epicyclic hypotheses of solar motion, the apparent anomaly of the Sun, and the derivation of mean motion (*Almagest* III.3-5 respectively) Bredon has appropriated from Ibn Aflah, duly cited. Means for calculating the Sun's position, the immediate objective of Book III, was achieved through William Rede's 1341-1344 solar tables, no doubt a spin-off of Bredon's study. At all events, it was the motion of the eighth sphere of fixed stars, a problem introduced in *Almagest* III.1, that truly fascinated Bredon. Hipparchus had

Snedegar, 'John Ashenden', 360.

³⁴ Bredon's highly annotated copies of Jabir's *Elementa Astronomica* and *Almagesti minoris*, and Richard of Wallingford's *Albion*, are contained in MS Harley 625; the *De sphaera* of Theodosius and Menelaos, *De anno solis* of Thabit ibn Qurra, and Wallingford's *Quadripartitum* in MS Digby 178.

³⁵ John Farley († 1464) left a suggestive note 'Totius celi circulus in 360 partes seu gradus dividitur cuius propria diameter sic reperitur (...) Bredon geometrice sic' by the chapter heading for I.10 in the beautiful New College *Almagest*, MS 281, fol.8v.

observed a difference between the Sun's annual motion with respect to the solstices or equinoxes and to the background stars, leading him to the idea that the sphere of fixed stars had its own very gradual motion. This article is no place to recount the complex history of the ancient and medieval theories of precession; suffice it to say that Bredon became involved. At the time of the *Commentum* all he could do was list values for the length of the tropical year given by Abrachis (i.e. Hipparchus), Thebith (i.e. Ibn Qurra), the Alfonsine Tables, and other authorities, and state that they were in disagreement. The citation of Ibn Qurra is doubly important, for Bredon possessed a copy of his *De anno solis*³⁶ and he would be motivated by the observations in it to seek observational data himself.

Unfortunately for his Ptolemaic program Bredon never advanced beyond *Almagest* III. (That is to say, he never got into the real meat of lunar and planetary theory.) The arrested development of his astronomical thought may be explained by the expedients of career advancement; there was no provision for advanced astronomical study in the university system. After finishing the regency in arts, one had, in general, either to enter one of the higher faculties (law, medicine, theology) or leave the academy. Bredon's choice of medicine in 1341 precluded a singular devotion to the greatest astronomy book ever written as there were so many medical classics now to digest. That is not to say that he turned his back on Ptolemaic astronomy. As late as 1347 he was scanning the heavens for insight—as I accidentally discovered a few years ago by reading in MS Harley 625 a previously neglected Bredon note which gives a detailed record of two observations by him.³⁷ In the predawn sky of 14 September 1347 he witnessed an appulse of Venus with the star Regulus (*Cor Leonis*); the planet passed so close to the star that Bredon could not discern them as separate objects.³⁸ Eleven days later he watched the Moon occult the star Aldebaran. It was unusual for a medieval astronomer to observe real-time events. Bredon must have been anticipating them, as he surely aware of the observations in *Almagest* VII.3

³⁶ Entitled *De motu Thebith* in MS Digby 178, fol. 9r-10v, utilized by F. J. Carmody for his edition of *De anno solis* in *The Astronomical Works of Thabit b. Qurra*, Berkeley 1960.

³⁷ Fol. 3v: 'Notandum quod anno Christi 1347 imperfecto in festo exaltationis sancte crucis in aurora Venus et Cor Leonis suos simul extendebant <illae> quod non potui discernere stella a planeta unde equavi ipsam ad 18 horam 13 diei mensis Septembris et fuit medius motus 6.7.48 medium centrum 3.8.8 medium argumentum 8.23.50 et verus locus 4.21.15. Item in anno supradicto in Septembri 14 hora 30 minut. secundum estimationem 25 diei eiusdem Luna eclipsavit Aldebaran Jove existente prope lineam meridiam et fuit in 10 g. Tauri in principio eclipsis sed in fine Luna fuit prope lineam meridionalem ex parte orient. et eius verus locus 2 sig. 44mi. eiusque vera latitudo meridional<is> 4 g. 44mi'. This note is fittingly appended to Bredon's copy of the Ptolemaic star catalogue.

³⁸ The minimum Venus-Regulus distance was less than ten minutes of arc that morning (Jean Meeus, personal correspondence, 1988). Nonetheless, Bredon should have been able to resolve the pair; perhaps his inability to do so is an indication of poor eyesight.

of ancient lunar occultations and those in Ibn Qurra's *De anno solis* involving Regulus particularly.³⁹ For the observed times of the occultations Ptolemy had computed the apparent positions of the Moon and hence the positions of the occulted stars, with the explicit purpose of determining the motion of the starry sphere. Regulus observations also occur in the *Almagest*, the most important sighting being utilized for the measurement of the star's elongation from the Moon (not an occultation) in order to fix the star's longitude. Decades later (the 1380s) Chaucer would wax poetically about Phoebus shining on the breast of the Lion. For Bredon, however, Regulus and Aldebaran were benchmark stars by which the movement of the eighth sphere might be calculated. In the case of the Venus-Regulus appulse Bredon compared the longitude of Regulus from the *Almagest* star catalogue, 122;30 (122 degrees; 30 minutes from the first degree of Aries), with a calculated position for Venus at the time of the appulse, 141;15. As he had observed the two objects so closely together that they could not be distinguished from one another, the eighth sphere must have shifted about 18;45 degrees (141;15 minus 122;30) since Ptolemy's time. For the occultation event the calculated position of the Moon was 60;44, the Ptolemaic longitude of Aldebaran 42;40, yielding a shift of 18;04 degrees. How Bredon handled the discrepancy between the two results is obscure; he is credited by others as having found the motion of the eighth sphere to have been eighteen degrees since Ptolemy.⁴⁰

It is well beyond the scope of this article, but illuminating research could be done on the relationship Bredon's data may have had with the anonymous astronomical tables compiled in Oxford for the 1348 epoch.⁴¹ In a real sense the 1347 observations came too late for Bredon to exploit himself. If immersion into medical training were not already enough to keep him distracted, the good fortune of surviving the Black Death would in itself make him rather too marketable as a physician. There would be no turning back.

³⁹ In A.D. 830/831 Ibn Qurra observed the star's longitude to be 133;13 degrees. *Astronomical Works of Thabit b. Qurra*, 53-43.

⁴⁰ An edition of Walter of Odington's *De motu octave spere* dating to 1397 cites the figure. North, *Richard of Wallingford*, iii, 244, 261. For the perspective of an intelligent contemporary of Bredon, see B. R. Goldstein, 'Levi ben Gerson's analysis of precession', *Journal of the History of Astronomy* 6 (1975), 31-41.

⁴¹ A so-called *canon optimus* to the 1348 tables names Bredon, Bradwardine, and William Batecombe as possible authors. North thinks Batecombe to be most likely. North, 'Alfonsine Tables', 279.

Trifolium de re medica

As a physician Bredon trod the path of John Gaddesden, who had distinguished himself as a medical scholar and subsequently attached himself to royal patrons. The career trajectories are notably similar in this respect. Gaddesden had been a Merton fellow in the first decade of the fourteenth century.⁴² His medical compendium, entitled *Rosa Anglica*, served as a nationalistic foil to the *Lilium medicinae* of Montpelier professor Bernard Gordon. Gaddesden became a king's clerk and was granted, on the petition of Edward III, canonries at St Paul's London and Chichester, notwithstanding his rectory of Chipping Norton. He also had licence to continue his Oxford studies well into the 1330s, Bredon's formative years. During the 1340s Gaddesden attended the king's daughter Joanna as well as the Prince Edward. His career culminated in 1346 when the Black Prince presented him with a golden rose as a New Year's gift, no doubt in reference to the *Rosa*.

The senior physician must have been a powerful role model for Bredon just as he was about to embark on his own medical career late in the 1340s. Bredon's *Trifolium de re medica* can be seen as integral to his career plans—a magnum opus designed to attract notice. The title *Trifolium* was something of a pun, for not only would the work be divided into three parts it was also intended to be the third (and by far the most encyclopedic) of the great flowerings of fourteenth-century medical writing. As it was, Bredon would never finish the effort. And although Oxford students would utilize it to the end of the fifteenth century, the *Trifolium* failed to receive anything approaching the general circulation of the *Lilium* or *Rosa*.⁴³

If the *Trifolium* dates to Bredon's regency in medicine in the 1340s it also conforms to the style of Merton scholarly writing in that decade, including Ashenden's astrological *Summa* (1347-48), and Bradwardine's theological masterwork, *De causa Dei* (1344). Each of these is massive, intricate, and densely packed with citations of traditional authorities. In fairness, it must be said that Bradwardine expressed his independent voice clearly through eight hundred pages of words mostly originating from Aristotle, Augustine and others. The compendiums of Ashenden and Bredon are equally competent in

⁴² BRUO, ii, 739.

⁴³ A fragmentary fifteenth-century copy of the *Trifolium* survives in MS Digby 160. What is described by Bredon's will as *questiones et lecturae medicinae* in two volumes appears in a fifteenth-century Merton College register as the *Trifolium*. J. Gerard borrowed the work from the library in 1477. Sometime later, John Hart bequeathed his copy of the *Trifolium*, also in two volumes, to the College library. In August 1484 the College petitioned John's brother Walter for the books, and, despite a long delay, had acquired them by April 1490. Both copies of the *Trifolium* have since vanished. *Registrum Annalium Collegii Mertonensis 1483-1521*, ed. H. E. Salter, Oxford 1921, 131.

amassing the words of the wise, but they were altogether derivative. The surviving fragment of the *Trifolium*, by Talbot's reckoning less than one-twelfth of the entire treatise, occupies 123 manuscript leaves. It is divided into three sections: on the analysis of urine, determining the utility of medicines, and interpreting the pulse. Bredon took care to provide exact references to his medical authorities in what was essentially a cut-and-paste effort at arranging large verbatim passages into a sort of Gothic unity comprising Galen, Avicenna, Constantinus Africanus, Theophilus, Albertus Magnus, John de Sancto Amando, among others. Michael McVaugh has determined that Bredon was not always forthcoming on the source of his information; the *folium* on medicines contains Bernard Gordon's *Tractatus de gradibus* as a major unreferenced subtext. At all events, historians of medieval medicine have viewed the *Trifolium* as a sterile compilation.⁴⁴

Doctour of phisyk

Whether or not his medical erudition assisted Bredon in cultivating what was to become a lucrative practice remains unknown, but his will shows signs of the key ingredient for success: aristocratic patronage. At some point he had contact with Elizabeth de Burgh, wife of Lionel the duke of Clarence; she presented him with a superior copy of Gaddesden's *Rosa*, which he left to his clerk Robert Valeys.⁴⁵ To Nicholas Chaddesdene he gave a silver cup engraved with the arms of Warenne. Richard Fitzalan, earl of Arundel (who styled himself Warenne after 1361), no doubt had originally presented the cup to Bredon. The extent of his relationship with de Burgh was probably limited; it is clear that Fitzalan's patronage made Bredon one of the best compensated medical practitioners of the day.

Although no record of a cash payment from Fitzalan to Bredon has been uncovered, it has long been understood that the grant of a church living was for the medieval aristocratic patron an ideal way of retaining a physician

⁴⁴ Talbot, 'Simon Bredon', 21-22. McVaugh's suggestion that Bradwardine may have derived his 'law' of motion from the account in the *Trifolium* of the Arnaldian-Alkindian theory of pharmaceutical potencies must be considered unlikely in the extreme. Quite apart from the lack of any direct evidence of medical influence on Bradwardine's thought, he composed *De proportionibus* two decades before Bredon compiled the *Trifolium*. M. McVaugh, 'Arnald of Villanova and Bradwardine's Law', *Isis* 58 (1967), 58-60. S. Drake effectively refuted McVaugh's proposal in 'Medieval Ratio Theory vs. Compound Medicines in the Origins of Bradwardine's Rule', *Isis* 64 (1973), 67-77.

⁴⁵ 'Item rosam meam que fuit domine mee de Clare lego Willelmo Valeys clerico meo et rosam aliam tenuioris voluminis lego aule de Merton'. Powicke, *Medieval Books*, 85. Elizabeth de Burgh endowed Clare Hall, Cambridge, and in 1359 promulgated its statutes allowing for twenty fellows including one medical scholar. D. Riehl Leader, *A History of the University of Cambridge. Vol. 1: The University to 1546*, Cambridge 1988, 82-83.

without incurring any direct expense. Bredon's first appointments—as vicar of Rustington, Sussex (May 1348) and rector of East Grinstead (November 1351)—are to be seen in this light; they almost certainly resulted from Fitzalan's sponsorship. One of the most lucrative benefices in Sussex, the rectorship of East Grinstead enjoyed an annual income of 40 pounds. By January 1354 Bredon had also become archdeacon of Chichester. Fitzalan explicitly endorsed a February 1355 papal petition of a canonry and reservation of a prebend in the Chichester diocese for Bredon. The earl must have valued the services of this unordained pluralist highly; he may have even sought Bredon's advice on the university education of his third son, Thomas.⁴⁶ If the Warenne arms on the silver cup are any indication, Bredon remained in Fitzalan's employ at least into the early 1360s.

In December 1356 Bredon exchanged the archdeaconry for a church living at Aldenham, Hertfordshire. A little more than a year after that Edward III's sister Joanna, queen of Scots, established her household at Hertford. Bredon's background and convenience of location were probably sufficient recommendation. He is recorded as attending physician to Joanna in the first week of September 1358. The queen's account book indicates that her steward authorized the payment of two pence for Bredon's horses, and sixty pence for the consultation. However, on the same occasion London apothecary Nicholas Thomasyn was paid over four pounds for various medicines.⁴⁷ Bredon's reward entailed his appointment as Warden of the Hospital of New Work at Maidstone, which archbishop Simon Islip confirmed on 11 September 1358.

Bredon rode the wheel of fortune in the 1360s. During this time the archbishop of Canterbury replaced the earl of Arundel as his major patron. An Oxford alumnus, Islip⁴⁸ provided Bredon with two Kentish rectories (Sevenoaks and Biddenden) and a canonry (Wingham). Medical attention was called for when in January 1363 Islip suffered a stroke, losing the ability to speak. Although the details of Bredon's service to Islip are unclear, the doctor was certainly residing at the archiepiscopal palace at Mayfield in 1364 when he became embroiled in a dispute with the Priory of St. Pancras at Lewes. Three years earlier the priory had retained Bredon '*pro bono et laudibili auxilio et consilio suo nobis et Monasterio nostro impenso et imposterum impendendo*' with an annuity of twenty pounds on condition that he vacate the rectorship of East Grinstead. The terms of the agreement were

⁴⁶ He would become, successively, bishop of Ely, archbishop of York, and Canterbury. M. Aston has speculated on Bredon's mentorship in *Thomas Arundel: A Study of Church Life in the Reign of Richard II*, Oxford 1967, 12.

⁴⁷ British Library, MS Cotton Galba E.xiv, fols. 41v, 53v.

⁴⁸ BRUO, ii, 1006-1008. Emden rejects Anthony Wood's assertion that Islip had been a fellow of Merton.

vague as to what sort of aid and counsel Bredon was to provide. (Could there have been any question that it was medical?) When Gerard Rothonis, the prior, fell ill and sent for the doctor, Bredon, then at Mayfield, refused to attend, provide advice or medication. The annuity therefore was canceled. Bredon took out a writ against the prior claiming thirty pounds arrears and one hundred pounds damages. The priory claimed nonfeasance by Bredon, voiding the contract. In court Bredon's advocate argued two points: that suffering from *gutta* (possibly, but not necessarily, gout) himself, Bredon had been unable to attend the prior, and, above all, that the annuity had not been granted for medical services, but for resigning the living of East Grinstead. The defense contended that medical service was implied in the deed of annuity. At no time was it denied that Bredon was a practicing doctor of physic, nor that he had failed to attend the prior. Further, the defense argued a parallel between legal and medical practice. Any grant *pro consilio suo habendo* made to a lawyer was assumed to be for legal services unless otherwise specified; a physician should be treated similarly. The judges seem to have been impressed with the defense arguments; after a year of adjournments (1365) they announced their verdict in the prior's favor. Despite the imprecision of the legal contract, the judges affirmed the necessity of a physician attending his patient.⁴⁹

The year 1366 marked a climacteric for Bredon. His dealings with the priory of Lewes had now lost him a valuable benefice and annuity. There were legal and other bills to pay, too. Bredon was discovering that the expense of maintaining the hospital at Maidstone was greater than its income. The temporalities of New Work amounted to little over five pounds per annum. The institution was intended to support ten invalid residents; each was to receive ten pence weekly. Such payments would have required an annual income of over twenty-one pounds. A visitation in 1375 found only five residents at New Work.⁵⁰ During Bredon's wardenship records show only three named residents; even so, the hospital's endowment could not adequately support them. Bredon petitioned for relief from a 1366 tax of twenty marks for this reason.⁵¹ If these financial worries were not enough, he also lost the support of his archiepiscopal patron: Simon Islip died on 26 April 1366. Fortunately, the prebendary in Chichester which had been reserved for Bredon a decade earlier became available, providing a new source of income. It was to be his last church appointment.

⁴⁹ My account is entirely founded on that of J. B. Post, 'Doctor Versus Patient: Two Fourteenth-Century Lawsuits', *Medical History* 16 (1972) 298-300.

⁵⁰ *Victoria History of the County of Kent*, ed. W. Page, London 1926, ii, 232-233.

⁵¹ *Registrum Simonis Langham Cantuariensis Archiepiscopi*, ed. A. C. Wood, Oxford 1956, 100-101. The same register names William de Elmeden, John Waleys and John Sperhauk as residents of the hospital.

His medical career and health in decline, Bredon gravitated toward Battle Abbey where he had a friendship with the abbot, Hamon de Uffington.⁵² He drafted his will at the abbey, requesting his burial there as well. This testament specified cash disbursements of some fifty pounds (a relatively modest sum considering what Bredon must have earned during his career), and granted expensive pieces of silverware and fur-lined clothing to several friends and relatives. By far the most valuable asset of his estate was a sixty-volume library, half of which was designated to go to individuals, the remainder to Oxford colleges: Merton (23 books), Balliol (3), Queens (2), Oriel, (1) University (1). Bredon's executors were to divide any residual assets among indigent parishioners, poor Oxford scholars, and virtuous young women. Such were the physician's last wishes.

Envoi

At the height of his career Bredon must have been the very image of Chaucer's 'doctour of phisyk'. The salient features of this *Canterbury Tales* character include a grounding in astronomy, the possession of a large specialist library, an impressive ability to diagnose disease, the unscrupulous prescription of costly drugs, an indifference to religion, love of flamboyant clothes and of gold.⁵³ Broad public ambivalence toward the social status of medical practitioners would not have necessarily promoted a lasting name for Bredon. The notoriety of his failed suit against the prior of Lewes may have colored what had been a positive image with a reputation for avarice; it would be a fleeting celebrity. With the passing of his generation the physician was forgotten. Bredon acquired a posthumous fame, such as it was, solely on account of the uneven dissemination of his astronomical legacy. Already in the late fourteenth century a Middle English text names him as one of the four great English astronomers of recent times.⁵⁴ In the 1480s Lewis of Caerleon, an indefatigable calculator himself, admiringly copied Bredon's *Almagest* commentary. A century later, John Dee in his advice to Queen Elizabeth on calendar reform memorialized Bredon as one of England's scientific heroes. John North is reasonably sure that Dee got all his information about Bredon from a single manuscript (part of what is now

⁵² A 'man of considerable character' according to the *Victoria History of the County of Sussex*, Vol. ii, 54. Bredon bequeathed to him a formulary, a law book, and a chalice.

⁵³ Apparently no one has thought of Bredon as a model for the doctour. The character is comprehensively reviewed in *A Variorum Edition of the Works of Geoffrey Chaucer*. Vol. II: *The Canterbury Tales. General Prologue*, ed. M. Andrew, Norman 1993, 359-396.

⁵⁴ The other three being John Ashenden, William Rede, and the Cambridge scholar Walter Elveden. Cambridge, Trinity College, MS O.5.26, fol. 112vb. North has published the Middle English text in, *Richard of Wallingford*, Vol. III, Appendix 19.

Digby 178), one which contains no direct biographical information. Dee also misinterpreted some of the astronomical matter in the codex.⁵⁵ Certainly by the 1580s Bredon's manuscript remains had been scattered, his astronomical books lost or dismembered. Ironically, over time the name of Bredon the astronomer has been remembered while only two of his astronomical books (Digby 168 and the Cotton-Harley-Digby codex) have survived. Seven of his medical volumes are extant. At all events, history should record that the astronomical and medical texts emerged from the continuum of a single human life that was itself, in a word, noteworthy.

⁵⁵ North, J.D., 'The Western Calendar—"Intolerabilis, Horribilis, et Derisibilis"; Four Centuries of Discontent', *Gregorian Reform of the Calendar. Proceedings of the Vatican Conference to Commemorate its 400th Anniversary 1582-1982*. ed. G. V. Coyne, S. J., M. A. Hoskin, and O. Pedersen, Rome 1983, 103.

APPENDICES

APPENDIX A. EXTANT MEMBERS OF BREDON'S PERSONAL LIBRARY

Oxford, Balliol College, 89. Avicenna, *Canon*.

Oxford, Balliol College, 306. Boethius, *Arithmetica*.

[Probably Bredon's gift.]

Oxford, Bodleian Library, Digby 168. Astronomical miscellany

Oxford, Bodleian Library, 179. Ptolemy, *Quadripartitum*

Oxford, Merton College, C.2.I (250). Gariopontus, *Passionarium*.

Oxford, Merton College, H.3.5 (231). Constantinus Africanus, *Pantegni*.

[Index in Bredon's hand.]

Oxford, Merton College, N.3.6 (223). Peter Quesnel, *Directorium juris*.

Oxford, Merton College, N.3.7 (224). Avicenna, *Canon*.

Oxford, Merton College, N.3.9 (226). Gilbertus Anglicus, *Compendium Medicinæ*.

Oxford, Oriel College, 2. Isidore of Seville, *Etymologiae*.

[Provenance uncertain.]

Oxford, Oriel College, 61. Averroes and Avicenna. [Provenance uncertain.]

Oxford, Pembroke College, 12. Alphabetical Herbal; *Practica Rogeri de Barona*. [Not mentioned in Bredon's will.]

London, British Library, Cotton Tiberius B.IX; Harley 625; and Oxford, Bodleian Library, Digby 178. Elements of these three manuscripts were originally bound together in a single volume owned by Bredon. See Watson, 'A Merton College Manuscript Reconstructed', *passim*.

APPENDIX B. MANUSCRIPTS OF WORKS ATTRIBUTED TO BREDON

Expositio arismetrice Boicii

1 Berne, Stadtbibliothek, A.50, fol. 180r-190r, ca.1412. Ascribed to Bradwardine.

2 Boston, Public Library, 103 (1531), 13 ff., s.xv.

3 Birmingham, Alabama, Reynolds Historical Library, MS 1, fol. 1-16, s.xiv.

4 Cambridge University Library, Ee.III.61, fols. 92v-101, s.xv.

5 Cambridge, University Library, additional 4087, fol. 172v-190v, s.xiv.

6 Madrid, Real Biblioteca del Escorial, i.II.6, fol. 63-70, A.D. 1489.

7 Oxford, Bodleian Library, Bodley 465, fol. 1-17, s.xv.

- 8 Oxford, Bodleian Library, Digby 98, fol. 109-117, s.xv init.
 - 9 Oxford, Bodleian Library, Digby 147, fol. 92-103v, s.xiv ex.
 - 10 Oxford, Corpus Christi College, 118, fol. 101v-113v, s.xv. In the hand of John Dunstaple.
 - 11 Paris, Bibliothèque Nationale, Cod. lat. 16198, fol. 151ra-155vb, s.xiv med.
 - 12 Princeton, New Jersey, Princeton University Library, Garrett 95, fol. 29-46, s.xv.
 - 13 Salamanca, Biblioteca Universitaria, 1693, fol. 38-44, s.xv.
 - 14 Augsburg, Staats- und Stadtbibliothek, qu. 21, fol 39r-61r, AD 1473.
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- 1 Cambridge, University Library, Ee.III.61, fol. 40-44, s.xv. Possessed by Lewis Caerleon.
- 2 Oxford, Bodleian Library, Digby 168, fol. 21r-39r, s.xiv med. Probably the *textus Almagesti tholomei* which Bredon left to University College, Oxford.
- 3 Oxford, Bodleian Library, Digby 178, fol. 42r-65, s.xv. Possessed by John Dee.
- 4 Paris, Bibliothèque Nationale, Cod. lat. 7292, fol.334r-345v, s.xv. Book I, propositions 8-13 only.

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Oxford, Bodleian Library, Digby 179, fol. 3-170, s.xiv med.

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Oxford, Bodleian Library, Digby 160, fol. 102-223, s.xv.

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London, British Library, Harley 321, fol. 46-53, s.xv.

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- 1 Cambridge, Corpus Christi College, MS 456.II, pages 77-126, s.xv.
- 2 Gloucester, Cathedral MS 21, fol. 17-33, s.xv med. In the hand of John Argentine.

⁵⁶ I am grateful to Dr. Menso Folkerts of the University of Munich for information on the last four manuscripts.

- 3 Lincoln, Cathedral MS 237 (A.7.7), fol.3-28r, s.xv.
- 4 London, British Library, Egerton 847, fol. 104v-122v, s.xv. Ascribed to Brytte.
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- 6 Norwich, Public Library, TC 28/1 (S.A.3.2), fol. 60-69, s.xv ex.
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- 9 Oxford, Bodleian Library, Digby 48, fol. 96r-114, s.xv. Ascribed to Bredon.
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SECTION THREE

EARLY MODERN PHILOSOPHY AND SCHOLARSHIP

LODI NAUTA

A HUMANIST READING OF BOETHIUS'S
CONSOLATIO PHILOSOPHIAE:
THE COMMENTARY BY MURMELLIUS AND AGRICOLA (1514)*

1. *The Consolatio in the later Middle Ages and Renaissance*

The popularity of Boethius's *Consolatio* has always been so overwhelming that it is easy to forget how exceptional it in fact was. For one can hardly think of another book that was translated and commented on so many times over a period of more than a thousand years. No other book, except for the Bible, attracted the attention of kings, the nobility, clerks, monks, and the laity alike. It influenced major writers such as Dante, Jean de Meun, and Chaucer, and it was an important source in scholastic debates on free will and divine foreknowledge, while it stimulated discussions on natural nobility at the courts of Western Europe.

A great number of medieval translations and commentaries are extant, and together with glossed copies of the *Consolatio*, they represent a vivid testimony of the great impact of Boethius on medieval thought and education. This medieval tradition, though by no means studied in all its aspects, has since long been subject of scholarly research, especially the translations by King Alfred, Notker, Chaucer and Jean de Meun, and their possible (Latin) sources.¹ The commentary tradition in the Renaissance and early modern period, however, has fared less well. In fact, it is still almost *terra incognita*. In this contribution, therefore, I have chosen to discuss an important

* I am grateful to Robert Black for his comments on an earlier draft of this article. A preliminary version of some parts of it has been published in an article co-authored by Mariken Goris, 'The Study of Boethius's *Consolatio* in the Low Countries around 1500: The Ghent Boethius (1485) and the Commentary by Agricola/Murmellius (1514)', in *Northern Humanism in European Context, 1469-1625. From the 'Adwert Academy' to Ubbo Emmius*, eds. F. Akkerman, A. J. Vanderjagt and A. H. van der Laan, Leiden 1999. Mrs Goris has kindly allowed me to reuse and expand on my part of our article.

¹ See e.g. the following volumes: *Congresso Internazionale di Studi Boeziani*, ed. L. Obertello, Rome 1981; *Boethius. His Life, Thought and Influence*, ed. M. Gibson, Oxford 1981; *The Medieval Boethius. Studies in the Vernacular Translations of the 'De Consolatione Philosophiae'*, ed. A. J. Minnis, Cambridge 1987; *Chaucer's Boece and the Medieval Tradition of Boethius*, ed. A. J. Minnis, Cambridge 1993; *Boethius in the Middle Ages. Latin and Vernacular Traditions of the 'Consolatio Philosophiae'*, eds. M. J. F. M. Hoenen and L. Nauta, Leiden 1997.

representative of this later tradition: the commentary of the northern humanist Johannes Murnellius, published in 1514. Let me begin by reviewing briefly the situation in the later medieval period.

In the later Middle Ages, Boethius was extremely popular. Several commentaries of a scholastic sort were composed in the fourteenth and fifteenth centuries, such as Pierre d'Ailly's from about 1380 (consisting of two *quaestiones*, each divided into, respectively, 8 and 6 *articuli*) and Denys the Carthusian's from about 1470, but at the end of this period humanist modes of reading and commenting on ancient texts began to prevail. This hermeneutic change was to some extent a natural development from medieval glossing techniques, and humanists were often indebted to their medieval predecessors for traditional historical and linguistic explanations.² The *Consolatio* had often been a school favourite (especially in northern schools), and though the reading of it had never been limited to the grammar school, this was certainly its principal place in the curriculum. We should, therefore, not expect too wide a gap between the medieval and humanist grammatical commentaries, especially in view of their close links to the schools. What seems to have happened to the *Consolatio* at the end of the Middle Ages is that it became even more a text predominantly read in grammar schools, thus limiting the range of types of commentaries. In Italy the preliminary Latin curriculum became exclusively the domain of grammar schools, while universities and *studia* provided for teaching in the higher disciplines, in law and medicine but also in philosophy (the so-called arts).³ Most late-medieval Florentine manuscripts, for example, reveal use as schoolbooks in the Italian grammar curriculum. The interlinear and, to a lesser extent, the marginal glossing show an overwhelmingly rudimentary style of comment, containing no philosophical, ethical or theological commentary whatever.⁴ This also holds true for Boethius commentaries by famous Italian teachers such as Pietro da Muglio (†1383), respected friend of Petrarch and Boccaccio, and, to a lesser extent,

² This is a large subject. For some good treatments see *Medieval Literary Theory and Criticism c. 1100 - c. 1375. The Commentary Tradition*, eds. A. J. Minnis and A. B. Scott with the assistance of D. Wallace, Oxford 1991², esp. the general introduction and chapters VIII and IX; A. Moss, *Printed Commonplace-Books and the Structuring of Renaissance Thought*, Oxford 1996, e.g. on Albertus de Eyb's *Margarita poetica* (completed in 1459 at the latest), which shows 'how much the study of classical poetry was still underpinned by the medieval grammar curriculum' (69).

³ R. Black in R. Black and G. Pomaro, *Boethius's 'Consolation of Philosophy' in Italian Medieval and Renaissance Education: Schoolbooks and their glosses in Florentine manuscripts*, SISMEL, Certosa, Florence (forthcoming in 1999)

⁴ Ibid. Cf. P. F. Gehl, *A Moral Art. Grammar, Society, and Culture in Trecento Florence*, Ithaca-London 1993, 152-158 (on Boethius); T. Ricklin, '...Quello non conosciuto da molti libro di Boezio. Hinweise zur *Consolatio philosophiae* in Norditalien', in *Boethius in the Middle Ages*, eds. Hoenen and Nauta, 267-286.

Giovanni Travesio (ca. 1411).⁵ Ascensius's commentary from 1498, which was reprinted several times in conjunction with the Pseudo-Aquinas commentary, can also be placed in this tradition, though it already represented a considerable improvement on earlier works as a result of the introduction of humanist learning.⁶

Although this sort of grammatical commentary became prominent—at least in Italy partly as a result of institutional specialization and changes in the intellectual climate—the scholastic commentary was not simply displaced, as can be seen from the widespread circulation of Trevet's commentary in the fifteenth century (cut down to manageable extracts for use in marginal glosses) and the Pseudo-Aquinas commentary, which ran into several editions. Scholasticism and humanism were of course not monolithic and homogeneous movements nor was the one replaced by the other. Scholasticism developed simultaneously with humanism, which is not surprising given the fact that, broadly speaking, scholasticism had a traditional stronghold in the universities, while humanists were often active at a pre-university level, viz. in the grammar schools. A comparison between the two in terms of schooling is therefore to compare like with unlike.⁷

The commentary of the northern humanist Johannes Murnellius, which is the subject of this chapter, still reflects something of the older tradition of grammatical commentaries, but goes far beyond that tradition, strongly supporting and propagating the ideals and programme of humanist education in the Low Countries. As such it must be considered as one among many examples, but seen in the context of the commentary tradition of Boethius, it is illustrative of the changes which the interpretation of the *Consolatio* underwent in this period of transition.

⁵ G. F. Vescovini, 'Due commenti inediti del XIV secolo al "De consolatione philosophiae" di Boezio', *Rivista critica di storia della filosofia* 13 (1958), 384–414, and the fine comments by Black in Black and Pomaro, 'Boethius's "Consolation of Philosophy"'.
⁶ *Commentum duplex in Boetium de consolatione philosophiae*, Lugduni 1498 (= Ps-Aquinas and Badius Ascensius). This commentary has not been properly studied. Its orientation is grammatical and stylistic, as can be seen from the many quotations from Lorenzo Valla's *Elegantiae*. For brief remarks see P. Courcelle, *La Consolation de Philosophie dans la tradition littéraire. Antécédents et postérité de Boèce*, Paris 1967, 331–332; O. Herding, 'Probleme des frühen Humanismus in Deutschland', *Archiv für Kulturgeschichte* 38 (1956), 344–389, on 352; P. G. Schmidt, 'Jodocus Badius Ascensius als Kommentator', in *Der Kommentar in der Renaissance*, eds. A. Buck and O. Herding, Boppard 1975, 63–71, esp. 66.

⁷ Cf. R. Black, 'Italian Renaissance Education: Changing Perspectives and Continuing Controversies', *Journal of the History of Ideas* 52 (1991), 315–334, on 324–325, who rightly criticizes A. Grafton and L. Jardine, *From Humanism to the Humanities. Education and the Liberal Arts in Fifteenth- and Sixteenth-Century Europe*, Cambridge, Mass. 1986 on this score. On the relationship between scholasticism and humanism see also the perceptive remarks in *Medieval Literary Criticism*, eds. Minnis and Scott, 9–10 and notes for further bibliography referring, for example, to the important scholarship of P. O. Kristeller; cf. C. C. Greenfield, *Humanist and Scholastic Poetics, 1250–1500*, London-Toronto 1981.

2. *Life and works of Johannes Murnellius*

Born at Roermond in 1480 into a poor family and soon an orphan, Murnellius attended at the famous Latin school in Deventer under the direction of Alexander Hegius (the same school which Erasmus had attended in the 1480s), and matriculated at the university of Cologne in 1496.⁸ He was a student of the Bursa Laurentiana, the stronghold of the *via albertiana*, devoted to the thought of Albert the Great, which was a powerful rival to the Bursa Montana, where the thought of Thomas Aquinas (or what was considered as such) was venerated. Cologne was an important university at that time, certainly not a backwater of pure scholastic philosophy as is often thought. As in Italy and elsewhere, here too humanist ideas developed simultaneously with scholasticism and were fostered rather than hampered by an interest in the thought of the great medieval theologians. Several of the theologians who were teaching in the Bursae had humanist interests. As Tewes writes in his monumental study of the Cologne bursae: 'spätestens in den neunziger Jahren [of the fifteenth century] muß der Humanismus an dieser Burse [i.e. Montana] unverrückbar in das traditionelle scholastische Lehrprogramm integriert worden sein', and the same is true for the Bursa Laurentiana.⁹ As an alumnus of the Bursa Laurentiana, it is therefore not surprising to find Murnellius composing a poem in praise of Albert the Great in 1507.

Friendships were cemented already in Deventer but especially in Münster. A key figure in this network of friends was Rudolph von Langen, who was a close friend of the Cologne Albertists.¹⁰ Von Langen, a devout and pious man and provost of Münster cathedral chapter was not only an enthusiastic advocate of humanist ideas but also full of admiration for Albert the Great. He belonged to the group of scholars, also including Alexander Hegius and Rudolph Agricola, that gathered around Wessel Gansfort in Aduard near

⁸ On Murnellius's life, see M. A. Nauwelaerts, 'Johannes Murnellius, Roermond 1480-Deventer 1517', in *Historische Opstellen over Roermond en omgeving*, ed. A. van Rijswijk *et al.*, Roermond 1951, 201-234 (with a chronological list of Murnellius's writings on 228-233); D. Reichling, *Johannes Murnellius. Sein Leben und seine Werke*, Freiburg im Breisgau 1880; the article in *Nieuw Nederlandsch biografisch woordenboek* I, 1348-1351 (by van der Velden); H. E. van Gelder, *Geschiedenis der Latijnsche School te Alkmaar*, vol. I, Alkmaar 1905, 39-45, 90-108, 149-155.

⁹ G.-R. Tewes, *Die Bursen der Kölner Artisten-Fakultät bis zur Mitte des 16. Jahrhunderts*, Cologne 1993, 683 and 726. Part V (pp. 665-805) of this extremely valuable study is devoted to 'Bursen-Humanismus und Bursen-Scholastik in Köln'. Murnellius is mentioned on 699-700, as well as in the section on the Albertists, several of whom became good friends of Murnellius (713-730).

¹⁰ See R. Stupperich and I. Guenther, 'Rudolph von Langen', in *Contemporaries of Erasmus*, eds. P. G. Bietenholz with the assistance of T. B. Deutscher, 3 vols., Toronto 1985-87, II, 290-291; Tewes, *Die Bursen*, 715-717. The influence of the Modern Devotion on Murnellius is often presupposed because of his contacts with men such as Rudolph von Langen, but should not be exaggerated, as Herding, 'Probleme des frühen Humanismus', 357 n. 52 correctly notices.

Groningen. Later, in 1500 he was able to reform the school in the Münster chapter by introducing a curriculum of humanist studies. Mummellius, who had become a licentiate in arts on 14 March 1500 and a master of arts in 1504, was appointed co-rector of the school by Rector Kemnerus on Von Langen's initiative. Mummellius taught in Münster for several years, first in the cathedral school, and later, after a dispute with Kemnerus, at St Ludgerus school, and still later once again in Kemnerus's school. Kemnerus was an alumnus of the Bursa Montana, and, as was often the case, the rivalry between the two Bursae may have added to the personal animosity between the two men.¹¹

In 1513 Mummellius accepted appointment as rector at the grammar school of Alkmaar, which then attracted vast numbers of students owing to Mummellius's reputation. After the sack of Alkmaar in 1517, Mummellius had to leave and taught briefly at Zwolle, before departing for Deventer where he was appointed rector at the St Lebuin's school. Within a month, however, he died suddenly at the age of 37. It was generally believed that he had been poisoned by another candidate for the Deventer rectorate, Listrius, but these rumours seem unfounded.

In his short life Mummellius published a great number of books, mostly intended for use in schools to replace the medieval textbooks; we know of at least 25 schoolbooks, 9 collection of poems and epigrams, and a complete list of his works would probably include more than 50 titles. His reputation as editor of (post-)classical texts, author of pedagogical works and poet brought him lasting fame, some of his works continuing to be printed and studied till the end of the eighteenth century. Among his works we meet typical products of a humanist teacher including the *Enchiridion scholasticorum* (on the duties and responsibilities of pupils), a humanist introduction to the Aristotelian categories¹², a successful anthology of Roman elegists, moralizing elegies (*Elegiarum moralium libri quatuor*), an ode to Münster, and a Latin primer, entitled *Pappia puerorum*, which run into 32 editions and must count as his most successful work. But without doubt his commentary on Boethius is his best work and has rightly been called 'a creditable piece of philological scholarship'.¹³

¹¹ Tewes, *Die Bursen*, 697-700.

¹² *In Aristotelis decem praedicamenta isagoge*, Deventer 1513.

¹³ C. G. van Leijenhorst and I. Guenther, 'Johannes Mummellius', in *Contemporaries of Erasmus*, II, 471. Cf. Nauwelaerts, 'Johannes Mummellius', 213: 'het filologisch meesterwerk'. Studies of the commentary are few: F. D'Elia, 'Il commento di Giovanni Mummellius al carne Boeziano "O qui perpetua"', *Miscellanea Francescana* 83, fasc. 3-4 (1983), 450-454 (a note on the famous III m. 9) and Herding, 'Probleme des frühen Humanismus', esp. 368-374.

3. The 'enarrationes autographas' of Agricola

Having already published an edition of the text of the *Consolatio* in 1511 with a few notes, Murmellius came forward with his scholarly commentary, which was published by Albert Pafraet in Deventer (1514).¹⁴ Like his collection of elegies, the commentary is dedicated to Rudolph von Langen, whom he also praises several times in his poems. In this letter of dedication Murmellius writes that Boethius deserved a better commentator than Murmellius himself, but he had been served even less well in the past. This was also the reason why other humanists edited Boethius or composed commentaries, as is clear from the prefaces and introductory material that Murmellius includes in his edition: their common intention was to rescue Boethius's text from the corruptions and impurities due to the medieval tradition, and to replace the often silly glosses from the late medieval commentaries (especially the work by Pseudo-Aquinas) with humanist annotations.¹⁵

A more striking and certainly more important insertion in his commentary is part of a commentary on the *Consolatio* by the famous Dutch humanist Rudolph Agricola, who had died in 1485 at the age of 41. Murmellius tells us that, when he was 20 years old (that is, in 1500) and had begun teaching in Münster, he came upon these 'enarrationes autographas'.¹⁶ From Murmellius's account it appears that Agricola had been asked for help in explaining Boethius's text by his friend Lambertus Vrijlinck of Groningen, a doctor in Medicine, who had received his degree in Ferrara, with Agricola as witness on 22 December 1478. This may suggest a date of composition in about 1475, the year in which Agricola moved to Ferrara to improve his knowledge of Greek, which at the time he wrote these notes was not yet very advanced. Agricola did not get far with the commentary, and the only part of the *Consolatio* for which we have his notes is from metre 4 to prose 6 of Book I, although Murmellius's words elsewhere suggest that he had not received all that was

¹⁴ The commentary was reprinted several times (Cologne 1516; Cologne 1535; Basel 1570, and in Migne, *Patrologia Latina* 63.869A-1074A). All quotations in this article refer to the reprint in Migne (though I have checked the editions from 1514 and 1570). As early as 1501 Murmellius lectured on the *Consolatio* (Reichling, *Johannes Murmellius*, 92 n. 3).

¹⁵ Murmellius (PL 63.869B), Nicholas Crescius (870C/D), James of Bologna (871B-878A), and Agostino Dati.

¹⁶ For Murmellius's account, see 908D-909C. There may also have been a connection with Cologne and, particularly, with the Albertists in the protracted and enigmatic story of the publication of Agricola's *De inventione dialectica*, viz. in the person of Pompejus Occo, who studied in the Bursa Laurentiana in 1504-1505. His uncle Adolf Occo, to whom Agricola had bequeathed his possessions on his death in 1485, bequeathed these in turn to his nephew Pompejus in 1503. See Tewes, *Die Bursen*, 711 and notes with bibliography; J. M. M. Hermans, 'Rudolph Agricola and his Books, with some Remarks on the Scriptorium of Selwerd', in *Rudolphus Agricola Phrisius 1444-1485*, eds. F. Akkerman and A. J. Vanderjagt, Leiden, 1988, 123-135 on 130, and L. Jardine, *Erasmus. Man of Letters. The Construction of Charisma in Print*, Princeton 1993, 83-128.

left of Agricola's comments on Boethius.¹⁷ Lambertus had shown these notes to Mummellius (probably on a visit to Münster). It seems that, on his sudden departure, Lambertus took the autograph with him but not before Mummellius or someone else had made a transcript.¹⁸ Mummellius had every reason to be excited about these comments (which he nevertheless published only after an interval of more than ten years). Agricola's name had spread far and wide, not so much as a result of his works on education (which were published only much later), but through Erasmus's repeated tribute to this great humanist and through his wide-ranging enquiries about the whereabouts of the manuscripts of the *De inventione dialectica* (for example made in the *Adagia* of 1508, known to Mummellius; he quotes it, for example, at 966C, 984C, and 1060C). It is hardly surprising then that by the time Mummellius came to publish his own commentary on Boethius, he took the opportunity to include Agricola's notes, 'lest they wither away any longer in my bookcase (*dactylothea*)', giving full credit to that 'uir tum doctissimus tum eloquentissimus'.

In my discussion I shall not always draw a firm line between the two commentators, since their approach and explanations are of the same character, possibly owing to some emendation on Mummellius's part.¹⁹

4. *Accessus and structure*

Mummellius begins his commentary with a prologue, listing a series of headings under which a text to be read in the class was analysed. He discusses Boethius's life and works, the title, the style, the intention of the writer, the number of books, its utility, and the part of philosophy to which it pertains. Though it had ancient roots, this type of *accessus*, 'type C' in Hunt's pioneering study of this genre, became widely popular in the twelfth century and it continued to be used both in Latin and vernacular writings in the later medieval period and throughout the Renaissance.²⁰ In Mummellius's prologue

¹⁷ 'Reliqua Rodolphi Agricolae quae in Boetium scripsisse fertur in manus meas non peruenerunt, quae utinam peruenerint! Nam ut haec, ita et illa sane quam libens tibi communicarem' (949C/D).

¹⁸ At one place, Agricola described his method of writing as disorderly, with many deletions: 'perplexe perturbateque omnia, deleta multa, multa traiecta, interlita...', *epist.* 18, ed. A. H. van der Laan, *Anatomie van een taal. Rodolphus Agricola en Antonius Liber aan de wieg van het humanistische Latijn in de Lage Landen (1469-1485)*, Groningen 1998, 214, though he had a clear handwriting (see *Rodolphus Agricola*, eds. Akkerman and Vanderjagt, Plate VI on p. 125). Perhaps the 'enarrationes autographas' about which Mummellius speaks had already been 'transcribed' and polished by someone else.

¹⁹ Only once does Mummellius take issue with Agricola, and rightly so, because there 'dignitatem' (not: 'indignitatem') is the correct reading (931D, on I pr. 4).

²⁰ R. W. Hunt, 'The Introductions to the *Artes* in the Twelfth Century', in *Studia mediaevalia in honorem R. M. Martin*, OP, Bruges 1948, 85-112; A. J. Minnis, *Theory of Authorship. Scholastic literary attitudes in the later Middle Ages*, Aldershot 1988² (1984¹), 17-28. For examples of this

there is an extensive albeit not original *vita*, using Procopius, Agnellus of Ravenna, Gregory the Great and Cassiodorus as his sources (including king Theoderic's letter to Boethius, according to Cassiodorus's *Variae* 1.45, also drawn upon by Trevet in his prologue). He omits and indeed explicitly rejects some of the explanations of Boethius's names, etymologically often incorrect, which are found in medieval commentaries. His remarks on Boethius's style do not concur with the standard medieval opinion, expressed in traditional *accessus*, that Boethius can measure up to Cicero in prose and Virgil in metre. According to Mummellius, Boethius's style is a 'middle style' ('mediocris') more philosophical than oratorical and, though unadorned and plain, not unworthy for an inquirer of truth.²¹ Mummellius is more in line with his medieval predecessors when he writes that the utility of the *Consolatio* is the discernment of true from false goods, thereby ultimately arriving at 'solidam perpetuamque beatitudinem bene honesteque vivendo' (885A), and that it pertains to moral rather than theoretical philosophy and to the active rather than to the contemplative life, though the ultimate part of the *Consolatio* borders on metaphysics and theology. Almost every medieval commentator had stressed the ethical aspect of Boethius and indeed of almost all grammatical *auctores*, including Ovid (in order to sanitize the meaning of Ovid's erotic poetry).²² Thus, Mummellius's point was a traditional one.

The structure of the commentary represents a conspicuous simplification when compared to the methods employed in scholastic commentaries. There are hardly any divisions of the text in *divisiones*, *partitiones*, *primo/secundo* and so forth (let alone *quaestiones*), which are prominent features of commentaries by scholars such as Nicholas Trevet, Pierre d'Ailly, Renier of St Truiden and Denys the Carthusian, features which were derided by Mummellius;²³ only an occasional 'sequitur' (e.g. 926C) reminds one of the medieval commentary idiom. Each section begins with a short introduction to that particular prose or

type of prologue in humanist commentaries, see *Catalogus translationum et commentariorum*, ed. P. O. Kristeller, Washington 1960-, vol. I, 205-6, 211, 212-213; vol. III, 248, 249 and 258; cf. *Medieval Literary Theory*, eds. Minnis and Scott, 14 n. 10.

²¹ 'Proinde ridiculum est quod indocti aiunt Boethium eo dictum Severinum, quod Theodorico regi se opposuerit' (883C/D). 'Stylus est mediocris, et philosophicus magis quam oratorius, non fucatus quidem aut phaleratus, sed qui veritatis inquisitori nequaquam improbetur' (884B). According to a standard *accessus* Boethius 'nec Tullio in prosis nec Virgilio in metris cederet' (ed. R. B. C. Huygens, *Accessus ad Auctores*, Leiden 1970, 47; cf. William of Conches, *Glosae super Boetium*, ed. L. Nauta, Turnhout 1999, at I pr. 4, lin. 527-28 app. crit.)

²² J. B. Allen, *The Ethical Poetic of the Later Middle Ages*, Toronto 1982; *Medieval Literary Theory*, eds. Minnis and Scott, 13-14. On Ovid see A. J. Minnis, 'Latin to Vernacular: Academic Prologues and the Medieval French Art of Love', in *Medieval and Renaissance Scholarship*, eds. N. Mann and B. Munk Olsen, Leiden 1997, 153-186.

²³ See his *Scoparius*, cap. 58 (in *Ausgewählte Werke des Münsterischen Humanisten Johannes Mummellius*, ed. A. Bömer, Münster 1892-95, Heft V, 48-49): '(...) supervacuis quaestunculis, obiectionibus, dilutionibus, sophismatis (...) etc.

metre, followed by an elucidation of words and phrases. Murmellius's procedure reflects the simple manner of glossing of a teacher, already long since practised in the schools.

Structure is perhaps too grand a word for what is in fact not more than a concatenation of glosses on words and phrases. Like so many other humanist commentaries on classical texts, Murmellius's work shows an overwhelming attention to philological niceties and tiny details, but an explication of philosophical arguments and their place in Boethius's train of thought is lost.²⁴ From his programme of teaching in the summer of 1511 we know that Murmellius intended to read with his pupils only the first two books of the *Consolatio*, and it is therefore not surprising to see that the last two, more philosophical, books attract far less attention than the other three.²⁵ Murmellius shows a bare modicum of interest in such philosophical issues as the metaphysical status of evil and the reconciliation of divine providence and freedom of the will. He is happy to direct the reader to Lorenzo Valla's *De libero arbitrio*, and to leave the question open to 'the judgement of wiser scholars' whether Valla had obscured rather than solved the problem of free will.²⁶ Boethius's use of the term 'fatum', which had caused some anxiety for medieval commentators, elicits only a string of definitions from older authorities, and likewise with the question of the existence of time, he does not commit himself to any of the given definitions.²⁷

The structure of medieval commentaries could at times be upset by the incorporation of long digressions on natural philosophical topics, evoked by Boethius's frequent allusions to planets, stars, comets, winds, and other cosmological and meteorological phenomena. Although in the humanist period too, commentaries continued to be used as a 'scaffold to be decorated with all manner of general information',²⁸ the nature of this general information was adapted to the prerequisites of the curriculum: to read and write classical Latin fluently. A modicum of science was welcome—Romans had written

²⁴ Cf. Grafton and Jardine, *From Humanism to the Humanities*, chapter 1, on the work of the famous 15th-c. humanist Guarino: 'There is little attention to Cicero's train of thought or line of argument—this is entirely lost in the scramble for detail' (p. 21).

²⁵ See the preface to his collection of epigrams where he announces (and thus publicizes) his projected programme of reading at the Ludgeri school in Münster (*Ausgewählte Werke*, ed. Bömer, Heft I, 18).

²⁶ 'Concludit humani libertatem arbitrii et diuinam praescientiam simul consistere: super qua re latius lege et relege Dialogum Laurentii Vallae, qui juste ne taxet Seuerinum nostrum, meliusque eo hanc materiam expediat, an sophisticis cavillis agat, et oratoris fucus obducatur ueritatem, non est nunc meae facultatis iudicare. Verum id censurae doctioribus relinquo' (1072C). Murmellius's turns of phrase suggest that he prefers Boethius's account.

²⁷ On fatum, see 1054D; on time 1023-1024. Cf. the catalogue of opinions on vision (1068B, on Boethius's words 'iactis radiis', V pr. 4; here Murmellius notes that Boethius follows Plato).

²⁸ Grafton and Jardine, *From Humanism to the Humanities*, 20 (on Guarino's commentary on the *Rhetorica ad Herennium*, believed by Guarino at that time to be a work of Cicero).

extensively on the quadrivial arts, after all—but in Murellius's work this is brought down to the bare minimum of some basic, traditional 'facts'.²⁹ More relevant to the average pupil was some knowledge of Roman history, daily life, geography and mythology, and on these topics Murellius offers some information when necessary (e.g. 920C/D).

5. *Philological niceties*

In the grammar schools of the fifteenth century, Boethius was primarily read for his Latin and his moral commonplaces (an aspect to which we shall return) rather than for his philosophy. Consequently, Murellius's notes and clarifications focus mainly on grammar, syntax, figures of speech, meaning of words, spelling, other linguistic phenomena and, only occasionally, formal aspects of argumentation. In places, this leads on to textual criticism and the emendation of readings which were found in the medieval manuscripts. The poor quality of manuscripts and early printed books made the activity of *emendatio*, even at an elementary reading level, a necessary job for the humanists. *Emendatio* is explicitly mentioned by Murellius in his *Enchiridion scholasticorum* (Cologne 1505) as an important element in the humanists' grammar syllabus: 'at the suggestion of his teacher, the diligent student should carefully correct (*emendet*) his textbooks'.³⁰ His commentary bears witness to the importance of *emendatio*. I shall give a few examples.

In metre 4 (line 11) of Book I, where Boethius speaks about 'cruel tyrants (*saevos tyrannos*) raging with no real power', Murellius writes that one should read 'feros' and not 'saevos', a reading which Rudolph von Langen had seen in 'quodam exemplari' twelve years ago when he was consulted by Murellius (913B).³¹ Rudolph von Langen is also credited with the reading 'excitantis' in stead of 'exagitantis' (I m. 4, line 6), which can be read in 'exemplaribus depravatis' but which is supposed to be unmetrical (913A). And in the same metre (line 2), Agricola wants us to read 'dedit' instead of 'egit' which 'many copies have' (910C). (Ironically, the most recent editor of the *Consolatio*, Bieler, has opted for the readings rejected by these three

²⁹ E.g. on the planets (896A/D, in fact a long quotation from Cicero's *De natura deorum*), on Venus and Mercury (935-936).

³⁰ Quoted by Moss, *Printed Commonplace-Books*, 88; Latin text from the *Opusculum de discipulorum officiis: quod enchiridion scholasticorum inscribitur* in Moss, 295 (= *Ausgewählte Werke*, ed. Bömer, Heft II, 55; on p. 54 Murellius voices the usual complaint about the poor quality of editions).

³¹ Von Langen had written two letters (dated 15 and 16 July 1501) on the text of the *Consolatio* to Murellius, which the latter published as an appendix to his *Epistolae morales* (reprinted in K. Krafft and W. Creelius, *Beiträge zur Geschichte des Humanismus am Niederrhein und in Westfalen*, 2. Heft, Elberfeld 1875, 33-34). Murellius incorporated Von Langen's suggestions in his commentary.

humanists.) In the next prose part, Agricola emends (correctly) 'percussus sumus' to 'perculsi sumus', quoting Tacitus to strengthen his case (920B).

To convey some impression of other types of notes and explanations, I shall give some further examples. Shifts of meaning are noticed, for example in a gloss on the word 'barbarorum' (917D). Here Agricola explains that the Greeks were wont to divide the whole human race into two categories: Greek and non-Greek, i.e. *barbari*. After the Greeks, Italians used the word to denote people devoid of 'humanitas et eruditio', and now Christians have appropriated the term to refer to non-Christians ('gentiles'). The negative connotation of the word 'tyrannus' is explained by its Greek origin and the Greeks' craving after freedom (911C). The influence of the vernacular is noticed at least once by Agricola, in the word 'stufa' (not used by Boethius of course), meaning 'heated room' or 'bath', for 'caldaria'.³² Formal aspects of argumentation are identified as in '*Nonne igitur bonum censes*] Syllogismus est tertii primae figurae modi' (1058C on IV pr. 7).

Many explanations traditionally involved etymologies, but there is a substantial difference in quality between the etymologies of the medieval scholar and the humanist's. Thus, Agricola gives etymologies, often taking into account a Greek origin, as in: '*Caminus*] A καίομαι Graece, quod est ardeo, dicitur' (911B). In typically humanist fashion a geographical note on Mount Vesuvius is added, stating that the Vesuvius should not be confused (what is often done by 'indocti') with the Vesulus in the Alps (cf. Mummellius on Vesuvius, 913A/B). Semantic precision is aimed at in many lexical explanations. Agricola writes on 'coelum' for example: 'Alii quasi caelatum, id est scalptum propter varias stellarum imagines arbitrabantur: unde et mundus ab ornatu dictus videtur: quemadmodum apud Graecos etiam κόσμος, id est mundus, ab ornatu dicitur; alii coelum ab eo quod Graece dicitur κοῖλον, id est cavum. Si primum dicatur, scribendum erit per ae diphthongum; si secundum, per oe. Nam quod vulgus dicit coelum quasi casam ἡλίου, id est solis, ineptum est, sicut multa indoctorum' (934B/C). Another example is offered by Agricola's note on 'auctoritas': after having listed some derivations which he thinks somewhat far-fetched ('longius quaesitum'), such as those stemming from 'augere' or from the Greek 'αὐτὸν', he prefers to spell the word without 'c' on analogy with 'fautum', derived from

³² 'quam hodie barbare stufam vocamus, secundum sonum Germanicae linguae' (911A). Cf. Ari Wesseling, 'Agricola and word explanation', in *Rodolphus Agricola*, eds. Akkerman and Vanderjagt, 229-235, who discusses a letter from Agricola to Hegius, in which a number of loan words are mentioned (not 'stufa' though). Wesseling assumes on account of the term 'corrupted words' ('corrupta') that Agricola 'condemned the introduction of vernacular loan-words into Latin' (231), but in the example quoted here Agricola includes himself among the users of such words ('vocamus'), 'barbare' probably meaning nothing more than 'not according to/found in classical Latin'.

'favere': 'et sicut a faveo fautum, sic ab aveo autum, quod est extra usum; et inde autor descendere videtur, quoniam is sit qui rem factam aveat, hoc est cupiat' (917B).³³ I shall give also some examples of Murnellius's use of Greek: 'Sirenes] Graece scribitur Σειρήν'. Falluntur igitur qui per υ scribunt. Nec a σύρω, id est traho, sed vel a σείω, vel (quod magis probant) ἀπό της σειρώς derivatur' (893D). When Boethius's diction reveals his debt to the Greek, this is noted too, as in 'notas insigniti frontibus' (branded on the forehead; I pr. 4): 'Figura loquendi Graeca', Agricola comments, for 'notis' would have been more correct (921A). 'Nihil puduit' in the same passage is a 'locutio Graecanica' (921C). 'Decretum' is glossed as corresponding with Greek δόγμα, 'quod indocti pro doctrina accipiunt' (924B). The examples are endless.

Murnellius may have already received his first lessons in Greek in the school at Deventer and later at Cologne in the class of Caesarius, a former pupil of the great humanist Lefèvre d'Étaples. In 1512 the rector, co-rectors and pupils alike of the chapter school in Münster are found attending lectures by Caesarius.³⁴ Owing to Murnellius's efforts, the study of Greek was introduced into the curriculum, whereby Münster became the first chapter school in Germany to offer teaching in Greek. His knowledge of the language was not particularly deep, as is clear from his simple lexical explications, but it enabled him at least to print in Greek characters (for the first time) Boethius's Greek quotations, which had up till then been transmitted in a garbled way or simply omitted. For their explanation, he had to call in the help of his friends, Caesarius and Joannes Aedicollus.³⁵

Sometimes Boethius is by Murnellius and Agricola criticized for his Latin. Living as he did in the early sixth century, he did not always meet the stand-

³³ For Agricola's knowledge of Greek see J. IJsewijn, 'Agricola as a Greek Scholar', *Rodolphus Agricola*, eds. Akkerman and Vanderjagt, 21-37; A. H. van der Laan, *Anatomie van een taal*, 181-190, with further references.

³⁴ Reichling, *Johannes Murnellius*, 79-81; Nauwelaerts, 'Joannes Murnellius', 202, 209-210, and 222.

³⁵ See e.g. 918C/D; 932A; 957B; 1056A. Though there is plenty of Greek in the commentary as published, it is not entirely clear whether the Greek was written in Greek characters by Agricola. In one place Murnellius states explicitly that Agricola had written the Greek expression "Ἄρα εἴ ὄνος πρὸς λύραν (i.e. an ass hearing the sound of a lyre; I pr. 4, line 2; this proverb is also quoted by Agricola in his letter no. 22, see van der Laan, *Anatomie van een taal*, 366) in 'Latinis litteris', perhaps because Lambertus, at whose request Agricola wrote these notes on Boethius, did not know Greek ('forsitan eo quod is cuius usus scriberet Graeca nesciret', 918C). Elsewhere Murnellius writes that Agricola seems to have put a Greek maxim in Greek characters: "Ἐπου θεῶ Sequere Deum: legitur autem hoc Graecum in exemplari quod mihi commodavit Caesarius, et in epistola Joannis Aedicollii ad me data... Porro Rodolphus Agricola videtur haec Graeca ponere θεῶ ἅλλ' οὐ θεοῖς, id est, Deo, et non diis (subaudi) servias seu serviendum' (932A). Aedicollus and Caesarius had supplied Murnellius with readings of Greek quotations in Boethius from 'old copies', probably Carolingian manuscripts (e.g. 'ex pervetusto exemplari', 957B).

ards of classical Latinity, and certainly not the humanists' ideal (or idea) of pure, classical Latin. His images and metaphors are sometimes not to the taste of humanist commentators. When Boethius writes, for example, 'compta colore' (decked in false colours; I m. 5, line 38), Agricola criticizes him: Boethius ought rather to have written 'tincta colore' (937D). Likewise, 'in sententia locatus' (holding to an opinion; I pr. 6) is called a 'frigida et segnis translatio' for 'locatam in eum sententiam' or 'nixus sententia' which would have been 'plainer and better' (948D). And in I metre 6 the woods are inappropriately called 'purpureum' (from the violets), because Boethius is describing winter, a season in which no violets are found (Agricola seems to rule out the possibility that the 'saevis aquilonibus' in the next line may blow in early spring). Boethius might however have alluded to the 'Greek property of word πορφύρεον, which is φυρόμενον, meaning totally confused and stirred up': the woods are heavily shaken by the winds of the winter (945B).

On the other hand, Boethius is sometimes defended against the far more severe criticisms of Lorenzo Valla, who had launched an attack on his philosophy and particularly his Latin, abounding as it did in ungrammatical substantives such as 'summum', 'bonum', 'unum', and 'ens'.³⁶ Although Valla had famously called Boethius the 'last of the Romans, first of the scholastics', it was especially the second part of this tag that summed up what Valla thought of him in the field of language, namely that with Boethius, and largely because of him, Latin had deviated from its classical path and deteriorated in successive ages. This concern for a return to classical Latin was shared by Agricola, of course, though he was less of a purist than Valla, vindicating words such as 'entitas' and 'Platonitas', which Valla wanted to abolish.³⁷ To give an example: 'Affectus', Agricola writes, is what the Greeks call πάθος, and what moderns, ignorant of the Latin spoken by Cicero and other classical authors ('nostri hodie ignari Ciceronis et aliorum auctorum Latine loquentium'), incorrectly call 'passio' (943A). Mummellius repeats the point later on (950A/B), but generally takes no heed of Valla's appeal to replace substantives such as 'summum', 'bonum' and the like with 'res'. At one place, he refers to Valla's *De vero falsoque bono* (book 3), but adds that here the great Valla was 'driven by too great a desire for quibbling and hairsplitting' ('nimia cavillandi libidine percitus'; 1047B/D). And elsewhere he defends Boethius's Latin against Valla's criticism.³⁸

³⁶ For Valla's criticism see *Elegantiae* 6.34 in his *Opera omnia*, 2 vols., Basel 1540, repr. Turin 1962, vol. I, 215-216. Cf. F. Gaeta, *Lorenzo Valla. Filologia e Storia nell'Umanesimo Italiano*, Naples 1955.

³⁷ See Wesseling, 'Agricola and word explanation', 230-231. On Valla's 'reconstruction' of classical Latin see e.g. D. Marsch, 'Grammar, Method, and Polemic in Lorenzo Valla's *Elegantiae*', *Rinascimento*, 2nd ser. 19 (1979), 91-116.

³⁸ L. Valla had missed a participle in 'solantur maesti nunc mea fata senis' (I m. 1, l. 8), but

These examples will hardly come as a surprise to readers of Renaissance editions of classical texts, but together with the impressive array of Greek, Latin, ancient and contemporary sources that Murmellius draws upon, they warrant, I think, the conclusion that his edition is indeed a creditable piece of philological scholarship, and that it may very well have been the first scholarly edition of the *Consolatio*, certainly more sophisticated than the grammatical commentaries from the later medieval period and that of Badius Ascensius of 1498, who had already started to move away from the medieval 'interpretatio Christiana'. But as was noticed above, a price had to be paid for this wealth of philological details and medley of information on history, mythology, geography and natural history: Boethius's philosophical arguments lie buried under this mass of details. But then, philosophical exegesis was not the aim of schoolmaster Murmellius.

6. *Platonism and allegory*

Boethius was recognized throughout the Middle Ages as a Christian author, but at the same time it was realized that Christianity was conspicuously absent from the *Consolatio*; hence, the urge was always felt to defend Boethius from critics (such as Bovo of Corvey, ca. 900) who associated him with the pagan Platonists. In his Boethius commentary, published in 1498, Badius Ascensius, however, had rejected the 'interpretatio Christiana' of the *Consolatio* without feeling that he thereby jeopardized its status as a morally edifying classic.³⁹

This de-christianization of the *Consolatio* became possible, of course, only when a wider knowledge of Boethius's time, culture and its pagan background began to be acquired. Like Badius Ascensius, Agricola and Murmellius felt that a sound interpretation of the *Consolatio* must take Platonic philosophy into account, without denying the fact that Boethius was a Christian. As Agricola writes: 'Boethius was not only a Christian, but also a follower of the old Academy of Plato' (946C). At times, however, even Murmellius cannot refrain from giving passages a Christian twist, for example where Boethius writes about the many ('multos') who 'have sought the enjoyment of happiness not simply through death but even through pain and suffering'. Murmellius glosses 'multos' with: 'Non Stoicos, neque Cynicos, sed magis Christianos martyres accipe' (968D on II pr. 4).⁴⁰ And Boethius's description

Murmellius writes that one should add 'facti', thereby getting the following paraphrase: 'Musae solantur nunc mea fata, qui ob fortunae iniquitatem factus sum moestus senex' (887B-C).

³⁹ Schmidt, 'Jodocus Badius Ascensius', 67-68; Courcelle, *La Consolation de Philosophie*, 331-332.

⁴⁰ Cf. 992A (on II m. 8, line 22). Murmellius does not gloss the other passage, where Boethius, according to many medieval commentators, was alluding to Christian martyrs (IV pr. 6.42, ed. L. Bieler, p. 83)—an example of Christian interpretation that Badius Ascensius had rejected

of marriage as a sacred bond is glossed by Mummellius as 'confirmed by the blood of Christ'.⁴¹

The allusions in the text to Neoplatonic doctrines such as the pre-existence of the soul, knowledge as recollection, the creation of the World Soul and the eternity of the world, are elucidated by ample quotations from, for example, Plato's *Timaeus* ('pulcherrimum librum', 1023A) and Macrobius's *Commentary on the Dream of Scipio*. Such typically humanist notions as the immortality of the soul and the divine origin of man's soul are emphasized.⁴² The regular occurrence, however, of phrases like 'ex Platonis doctrina', 'ut Platoni placet' and 'ut Platoni visum est' must make it clear that Mummellius, knowing that Boethius was more of a Platonist than an Aristotelian ('magis sit Platonicus quam Aristotelicus'; 1066C), cannot always share Boethius's Platonism: the notion of the soul's preexistence is rejected as 'vanissimum' (1036B); Plato is said to use 'summa et incredibili eloquentia' (1037A/B) and the authority of Augustine ('omnium mortalium longe doctissimus', 1024C) is invoked, though not quoted, to refute this 'Platonicum dogma' (1036B).⁴³ The concomitant notion of recollection of knowledge is explained in medieval fashion, using the subjunctive contrary to fact: the soul would have known all the things it could possibly know, if the body had not weighed it down.⁴⁴ And the Boethian 'seed of truth', remaining in the soul after embodiment, is vaguely described as a certain principle and beginning by which man is suited to perceive truth and acquire knowledge' ('Principium et inchoatio quaedam qua est homo veritati percipiendae et acquirendae scientiae naturaliter aptus', 1036C). Yet, it is clear from the ample quotations from Plato and Platonic authors such as Ficino, as well as the noncommittal way in which they are often presented, that Mummellius considers his role as commentator primarily to consist in clarifying philological points and providing sources (from which

(*Commentum duplex in Boetium*, p. 267, quoted by Courcelle, *Consolation de Philosophie*, 332).

⁴¹ Mummellius reads 'sanctos' in stead of 'sancto' in 'Hic sancto populos quoque iunctos foedere continet (...)' (II m. 8, l. 22-23), and comments: 'Sanctos] Justos, pacis amantes, Christi sanguine confirmatos. Vel sanctos, factis sacris et iuramentis praestitis consociatos' (992A).

⁴² E.g. on III m. 2: 'Unde probat hominis originem coelestem esse, et a summo bono profectam' (997C).

⁴³ I cannot therefore agree with D'Elia, who suggested (without much evidence) that 'Mummellius '[s]equendo questa precisa linea ermeneutica di convergenza del carne boeziano [i.e. III metre 9] con la dottrina biblico-patristica (...) è indotto a minimizzare la concezione dell'anima del mondo e della preesistenza delle anime' ('Il commento', 453). On the history of these Platonic notions, see my 'The Preexistence of the Soul in Medieval Thought', *Recherches de Théologie ancienne et médiévale* 63 (1996), 93-135, and my 'Platonic and Cartesian Philosophy in the Commentary on Boethius' *Consolatio Philosophiae* by Pierre Cally', *British Journal for the History of Philosophy* 4 (1996), 79-100.

⁴⁴ 'Gravitatem perturbationum et oblivionem, non eorum quae quis in alia vita novit (nam homini antequam nasceretur, aliam vitam fuisse sentire vanissimum est), sed eorum quae apta esset suapte natura (nisi corpori infunderetur, conjugereturque) anima cognoscere' (1036B), followed by Sap. 1.9, which was always quoted at this place by commentators on Boethius.

moral lessons could be drawn) rather than in giving verdicts on the doctrinal soundness of the opinions expressed in the text. Thus he even warns the reader that, although Plato's opinions on the world soul and on souls of lesser beings are not approved of by all Christians, 'Boethian Philosophy follows Plato carefully (*diligenter*) and prudently (*caute*)', and in turn Mummellius 'will expound carefully the elements (*singula*) of Platonic doctrine'. A brief catalogue of opinions on the question whether the heavenly bodies are animated must corroborate the same point, viz. that it does not matter which position one takes 'quantum ad Christianam doctrinam spectat' (1029C/D).

Another aspect of Mummellius's interpretation is the apparent absence of a desire to read more into the text than is in fact there. The medieval bent for allegorization is discarded, leaving thereby more room for the humanists' interest in philology and history. Thus, the Orpheus myth at the end of Book III, as well as other mythological passages, are dealt with in a cursory way and are not treated as *integumenta*, that is, the cloaking of more profound (Christian) meanings. Nevertheless, Mummellius follows in the footsteps of his medieval predecessors when he briefly summarizes the standard medieval interpretation, initiated by William of Conches: 'Quam [sc. fabulam] quidem sic interpretantur: Orpheus uxorem habuit Eurydicen (...). Est autem Eurydice humana anima (...)' (1039B/C). He draws also the distinction between 'fabula' and 'veritas', which we find in medieval commentaries (for example in William of Conches): 'Hic secundum Fabulam Vulcani filius fuit (...). Veritas tamen secundum philologos et historicos hoc habet, hunc fuisse Evandri nequissimum servum ac furem' (1062A). On the whole, however, Mummellius steers clear of allegory.

In this context, there is an interesting remark by Agricola, who notes that Boethius's pervasive use of medical metaphors, such as milder and stronger medicines to cure the patient Boethius, turns the *Consolatio* almost into 'allegoria' (943B). It is clear that this emphasis on the literal sense has a different ring from that in medieval hermeneutics. For medieval scholars the *Consolatio* could be read at several levels, and the term 'allegoria' was especially used for denoting the deeper meanings, for example, of the Orpheus fable and the myth of the creation of the world in the Platonic hymn in Book III, m. 9. The most that Mummellius will allow by way of a figural sense, on the other hand, is the hardly surprising reading of Lady Philosophy as 'recta ratio' and Boethius as a 'homo fortunae adversitatibus afflictus' (889B).

7. '*Studium duplex est: morum et litterarum*'

Apart from the *Accessus*, in which Mummellius, like almost all his medieval predecessors, duly stated that the study of the *Consolatio* pertains to ethics, his commentary frequently underlines the high moral-proverbial value of the

Consolatio. He regularly exclaims: 'Sententia celebrata' (972A), 'Pulchra verissimaque conclusio' (964A), 'Pulchra exclamatio' (981B), 'Vetus proverbium' (1003C), 'Sententia est notissima' (1008A) and 'Vetus adagium est' (1021B), impressed as he was not only by their edifying contents but also by their stylistic value.⁴⁵ He provides strings of quotations not only to illustrate moral maxims but also to explain phrases, apparently picked up at random from the *Consolatio*. Boethius's dictum 'nobody is free from care in this life' (II pr. 4) is called 'a very true *sententia*', which is illustrated with sayings from Hermogenes, Seneca, Horace, 'Erasmus e Graeco', Euripides, Pliny, Livy, Homer (in Filelfo's version), and Claudian (966B-967A). In the same section, pithy sayings on the mixture of sweet pleasure and sorrow are quoted from Plautus, Apuleius, Ovid, Salomon, and Lucretius. The age-old maxim 'Nature is content with few things and small' (II pr. 5) is illustrated with corroborating sayings from Turpilius, Seneca, Lucanus, Gellius, Cicero, Ambrose, Jerome, the Bible, and Prudentius. The maxim 'He who is silent and speaks at the appropriate time, is wise' (II pr. 7) is exemplified by quotations from Salomon, Diogenes and Thales (indirectly quoted of course), Ecclesiastes, Seneca, Macrobius, Valerius Maximus, and Donatus (986A/B). The examples are endless, and demonstrate the extent to which the *Consolatio* was regarded by Murmellius, like by so many other readers in the Middle Ages and Renaissance, as a storehouse of proverbial wisdom and moral maxims.

Recent scholarship, however, has questioned such an enhanced preoccupation with morals in the classrooms, in particular with reference to Italian humanist education. Was there any serious preoccupation with moral philosophy in daily classroom activities apart from the elevated claims humanists made when they advertised or defended their curriculum in prefaces, orations, letters and other appropriate literary genres? Previous generations of scholars often took the humanists' elevated claims at face value, claims to the effect that their training was essential for turning pupils into virtuous and wise persons, fit to be employed by the ruling élite of state and church. The impact of humanist education on society and its ruling classes was taken for granted. Garin, for example, arrived at the following description: 'Such was humanistic education: not as one has sometimes been led to believe, grammatical and rhetorical study as an end in itself, so much as the formation of a truly human consciousness, open in every direction, through historico-critical understanding of the cultural tradition. *Litterae* (literature) are effectively the means of expanding our personality beyond the confines of the present instance, relating it to paradigmatic experience of

⁴⁵ *Sententia* was also a rhetorical figure, as Robert Black reminded me; see e.g. *Rhetorica ad Herennium* 4.24-25.

man's history (...)'.⁴⁶ However, closer scrutiny of humanist teachings, laid down in lectures, commentaries, notes, contemporary records from pupils and so forth, shows an overwhelming preoccupation with philological details, and this raises the question whether previous scholars have not been taken in by the humanists' boasts. Grafton and Jardine, for example, have argued that 'the ideology of Renaissance humanism is being taken over as part of a historical account of humanist achievement',⁴⁷ but that the historical evidence does not match the humanists' elevated claims about the saving, civilising qualities of their education. Influenced by modern critiques of educational ideologies (for example by Pierre Bourdieu), these scholars have gone further and argued that as a result of the inadequacy of the practical classroom activity to match the fervour of the humanist ideal, 'western Europe as a whole (...) became involved in the mystification of arts education—a connivance in overlooking the evident mismatch between ideals and practice—which has clouded our intellectual judgement of the progress and importance of the liberal arts from the days of Guarino down to T. S. Eliot, Leavis and the twentieth-century guardians of European "civilisation"'.⁴⁸ A gap between ideals and daily practice is of course a phenomenon not limited to the classroom of the late-medieval and early modern period, but because the humanist programme is believed to lie at the root of modern lofty conceptions of a liberal arts education, the foundations of which are under attack by modern cultural critics, it is especially the 'ideology' of the ancestors of such an education that is sought, rightly or not, to be unmasked.

Others too have seriously questioned the preoccupation with morals in grammar teaching in the face of the abundance of philological details in commentaries and lectures. Black and Pomaro have made an extensive study of manuscript schoolbooks from Florence and come to the conclusion that 'in view of how the *Consolatio* was read and glossed in schools (...) it is clear at least that Renaissance teachers and pupils did not look to Boethius for moral inspiration and guidance'.⁴⁹ Grendler, though still holding firm (unlike Grafton and Jardine, and, though for different reasons, Black) to the conviction that the Renaissance was an era of revolutionary change for the better in terms of education, has pointed to the absence of moral lessons in humanist commentaries: 'Despite the barrage of humanistic assertions that Terence taught virtue, printed commentaries did not draw out moral lessons

⁴⁶ E. Garin, *Educazione umanistica in Italia*, 7, quoted by Grafton and Jardine, *From Humanism to the Humanities*, 25. Cf. Black, 'Italian Renaissance Education', 315-334, for the historical roots of Garin's position in Crocean, neo-Hegelian idealist philosophy.

⁴⁷ Grafton and Jardine, *From Humanism to the Humanities*, 3.

⁴⁸ *Ibid.*, xiv-xv.

⁴⁹ See Black in Black and Pomaro, *Boethius's 'Consolation of Philosophy' in Italian Renaissance Education*. Cf. Black, 'Italian Renaissance Education'.

but confined themselves to expository paraphrase, grammatical analysis, and explanation of unfamiliar persons and terms'.⁵⁰ And the same can be said of commentaries on Horace, Caesar, Sallust, and Valerius. But when he comes to speak about 'moral philosophy' as such, Grendler writes that, although 'Renaissance pedagogues neither taught a separate subject called moral philosophy nor read specific texts for that purpose', they 'extracted moral lessons from curricular texts. Practically any story of a virtuous or wicked deed might serve as the springboard for a lesson in morals'.⁵¹ Moral and commonplaces were written down and memorized by pupils, and the very same authors—Terence, Horace, Caesar, Sallust, Valerius Maximus—which were just said to have received merely philological glosses, are now held to be responsible for moral values such as honesty, moderation, loyalty, that is, 'a conservative morality of discipline, fortitude, and respect'.⁵²

The same sort of ambiguity is found in a recent book by Paul Gehl.⁵³ He suggests that the curriculum in elementary classes in trecento Florence consisted of a highly restricted list of pagan and Christian texts (the Donadello, Cato, Aesop, Prosper, Prudentius, and Boethius). This claim, however, is unsupported. In fact, there are many examples of classical texts read at a level no less elementary among Florentine manuscripts.⁵⁴ According to him, these texts were chosen for their moral contents: 'the purpose of the *studia humanitatis* was the moral reform of the individual and even of society. The trecento humanists consistently put their reforms in a Christian context, not just for political expediency or to advance their careers [motives which have been strongly emphasized by Grafton and Jardine, LN], but also because they had a deep commitment to the spiritual life'.⁵⁵ But here too, the available evidence points in another direction. Gehl himself notices that it is often difficult to say exactly how a text was approached in classroom teaching and that 'the elementary commentary tradition does not go deeply into moral lessons; it is necessarily concerned with the essentials of getting the student through the texts linguistically'.⁵⁶

It is beyond my competence to enter into this debate on the moral aspect of humanist education and the consequences of the failure of humanists to put into practice what they taught in theory, but a discussion of Murmellius's

⁵⁰ P. F. Grendler, *Schooling in Renaissance Italy. Literacy and Learning 1300-1600*, Baltimore-London 1989, 252, and 252-263.

⁵¹ *Ibid.*, 263.

⁵² *Ibid.*, 264.

⁵³ *A Moral Art. Grammar, Society, and Culture in Trecento Florence*, Ithaca-London 1993.

⁵⁴ As Robert Black has suggested to me in private correspondence.

⁵⁵ *Ibid.*, 2; see also 13, and *passim*.

⁵⁶ *Ibid.*, 17; cf. 83. Gehl's study however is seriously marred by various shortcomings, e.g. his arbitrary exclusion of MSS signed as schoolbooks (see Black in Black and Pomaro, *Boethius's 'Consolation of Philosophy in Italian Renaissance Education*).

methods and aims may throw some light on the seeming discrepancy between the absence of any overtly moral teaching and the preoccupation with morals by grammar teachers. In piling up quotations, Mummellius could draw on a great number of *florilegia*, commonplace-books, dictionaries, and various kinds of reference books, which were flooding the printing market in the fifteenth and sixteenth centuries, but had already long histories behind them. The practice of excerpting, collecting and arranging quotations, arguments, commonplaces and similar categories of memorable words, was of course a time-honoured affair, already advocated by Pliny, Seneca and other ancient authors, who often used the metaphor of bees gathering the nectar from various flowers.⁵⁷ In the Middle Age too, *florilegia* and other kinds of reference books were widely dispersed, often as part of encyclopedic works, and answered the needs of preachers, to mention only one important group of users. In addition to all this material, which could reach humanists through various channels, they themselves were busy bees as well, culling honey from an ever increasing field of flowers. In an interesting passage from his *Opusculum de discipulorum officiis* (Cologne 1505), which is essentially a guide to student reading, Mummellius describes this method of culling honey and recommends it to his pupils:⁵⁸

Not inadvisedly, but at the suggestion of his teacher, the diligent student should carefully emend his textbooks, pick out phrases and pithy remarks (*sententiae*) by inserting indicators (*versa puncta*), put a mark against the most memorable passages (*loci*), or, better still, excerpt them, and write what he has extracted in a little book designed for the purpose (...) Remarks which relate to the same subject-matter should be noted down and collected together in one particular place in the notebook (*in unum quendam locum*).

Thus, the inculcation of moral lessons and the learning of Latin were of course two sides of the same coin. Mummellius's phrase 'Studium duplex est: morum et litterarum' is yet another restatement of the perennial theme that good morals are inherent in good Latin. He goes on to list the works from which these phrases and pithy sayings are to be extracted: Cato (i.e. the *Disticha Catonis*), Seneca's *De quattuor virtutibus* (in fact by Martin of Braga), 'a golden book' by Isocrates (probably *Ad Demonicum*) and Jacobus

⁵⁷ Cf. Moss, *Printed Commonplace-Books*, 32: 'Reading, marking, learning, digesting, and regurgitating excerpted passages was a universal habit of the West-European literate community. It was also a habit that could cloak significant changes'. I am much indebted to this excellent book. On the bee-metaphor, see *ibid.*, 12 (on Seneca), 14 (Macrobius), 87 (Mummellius). The literature on commonplaces is vast, but mention must be made of the seminal work by E. R. Curtius, *Europäische Literatur und Lateinisches Mittelalter*, Bern-München 1973⁸ (1st ed. 1948), 79f., 80, 109 and *passim*.

⁵⁸ Quoted and discussed by Moss, *Printed Commonplace-Books*, 88. For the Latin text, see *ibid.* 295 or *Ausgewählte Werke*, ed. Bömer, Heft II, 55.

Wimpfeling's *Adolescentia*.⁵⁹ Latin grammar should be learnt with the aid of the standard manuals by Perotti, Guarino of Verona, Mancinelli, and other humanists. At a more advanced level, the student should learn Latin syntax 'from short phrases excerpted from classical prose-writers and poets, which demonstrate the same construction and contain edifying and interesting maxims and examples, so that "by constant repetition they may be imprinted on the memory"' (*crebra repetitione memoriae quasi imprimantur*).⁶⁰ Works that do not teach decent matter are to be avoided.

A good example of Murnellius's method is a collection of quotations from the three elegiac love poets, *Ex elegiacis Tibulli, Propertii ac Ovidii carminibus selecti versus magis memorabiles atque puerorum institutioni aptiores* (Deventer 1503¹), which, as the title indicates, brought together 'useful' phrases, carefully selected by the teacher from this 'turpis materia'. These extracts with short explanatory headings, called by Murnellius 'argumenta', should be read and memorized for moral improvement. Another illustration of the reading and excerpting habits of Murnellius is his humanist creed, the *Scoparius in barbariei propugnatores et osiores humanitatis* (1517-18), that is, the broom against the defenders of barbarism and enemies of humanism.⁶¹ It is a humanist vademecum what to read and above all what to avoid, and as such a concatenation of quotations from a vast number of works. Its tone is highly polemical, attacking the language, books and methods of the scholastics.

Murnellius's work is aptly described by Moss as a 'combination of moral discipline and methodical learning, applied to a programme of study which reflects the linguistic and literary focus of Italian humanism', and though she does not mention the Boethius commentary, her description fits this work perfectly as well.⁶² In it we see Murnellius applying the fruits of his labours to the explication of a school text. The study of the *Consolatio* served two main aims: a sound grasp of the Latin language in all its facets and an emphasis on a universal ethics, shared by pagan and Christian authors alike. Far from functioning solely as literary adornments, these quotations helped to give the *Consolatio* its place in a wider network of edifying works, which comprises not only pagan but also Christian literature (including the Bible), and ancient as well as modern. Such quotations and extracts, carefully selected by the

⁵⁹ *Ausgewählte Werke*, ed. Bömer, Heft II, 57.

⁶⁰ I quote Moss's paraphrase, *Printed Commonplace-Books*, 89; Latin text on 295 (= *Ausgewählte Werke*, ed. Bömer, 58). Cf. also Grendler, *Schooling in Renaissance Italy*, 263-264.

⁶¹ *Ausgewählte Werke*, ed. A. Bömer, Heft V. On this work see Nauwelaerts, 'Johannes Murnellius', 222-224 ('zijn humanistische geloofsbelijdenis'); Herding, 'Probleme des frühen Humanismus', 357-358, and esp. J. V. Mehl, 'Johannes Murnellius' *Scoparius* (1517-18): Another German Defense of Humanistic Study', *Acta Conventus Neo-Latini Torontonensis*, ed. A. Dalzell et al., Binghamton, NY, 1991, 471-480.

⁶² *Printed Commonplace-Books*, 87.

teacher, were the vehicles by which classical literature was delivered to the youth, and they helped to convey the idea of compatibility of the moral sayings from all these different works. In the case of Murnellius, this programme, marked by a love for the classics but at the same time by moral restrictions on the reading of them, may owe something to his contacts with Rudolph von Langen and the circle of pious Albertists in the Bursa Laurentiana at Cologne, where Murnellius had been taught, but it was of course not limited to this group of scholars. It is a characteristic feature, for example, of the programme of Jacobus Wimpfeling, who was, even more than Murnellius, suspicious of the moral influence of especially the Roman poets on young minds, and advocated the replacement of these elegiac poets and Martial by Christian authors such as Sedulius, Prudentius, Battista Mantuan, Buschius and Murnellius.⁶³

The notion that good Latin is in itself the vehicle of good moral training is of course one of the basic assumptions of the *studia humanitatis*. Although a pragmatic approach towards language teaching may often have been the more dominant one,⁶⁴ that grammar teaching also aimed at the inculcation of moral lessons is shown by the selection of the texts quoted, the way they are quoted (viz. as moral maxims and commonplaces), and the notion that close reading itself was believed to engender morality.⁶⁵ The absence of explicit moral teaching can thus be reconciled with a predominantly philological nature of commentaries. Much also depends on our understanding of 'morality' in this context. Murnellius's morality was of a practical kind, which had more to do with everyday 'virtues' such as decent behaviour and assiduity, modesty and moderation than with elevated notions such as truth, goodness, freedom, immortality of the soul and civilisation, with which the humanist programme in upholding the 'dignitas hominis' was credited. If morality is not identified with the extravagant claims, sometimes made by humanists for the saving, civilizing qualities of their teaching, the gap between practice and theory in

⁶³ The two northern humanists recommended each other's work: see letter no. 344 in *Jakob Wimpfeling. Briefwechsel*, eds. O. Herding and D. Mertens, Munich 1990, vol. II, 845-846, which he wrote 'ut ab eis grammatica pure et sincere absque faecibus et paleis iuventuti traderetur' (cf. Murnellius's phrase 'turpis materia' quoted above). Murnellius refers to Wimpfeling in his *Opusculum* (see above). On Wimpfeling see Herding, 'Probleme des frühen Humanismus', esp. 348-361 on the 'Motiv Tugend und Latein', and his excellent introduction to his ed. of Wimpfeling's *Adolescentia*, Munich 1965; cf. Moss, *Printed commonplace-books*, 84.

⁶⁴ The remark by Walter Ong seems to me too sweeping (but perhaps inspired by the pragmatic approach towards learning by Ramists): 'Latin was certainly not taught to "form character" or to "train the mind". These are rationalizations which appear only with the nineteenth century when it was on its way out.' In the Renaissance and long thereafter, 'such rationalizations were uncalled for and unreal' (*Ramus, Method, and the Decay of Dialogue*, Cambridge, Mass. 1958, 11).

⁶⁵ On this last point see Grafton and Jardine, *From Humanism to the Humanities*, 22-23 n. 52 and 148-149, and Black, 'Italian Renaissance Education', 330.

humanist schooling is not necessarily as wide as some scholars have made us to believe.

Trecento Florence and quattrocento Ferrara are not sixteenth-century Münster, and it would be unfair to compare copies of school texts glossed by Italian schoolboys with Murmellius's published commentary. The context, however, is roughly the same, viz. the grammar school, though Murmellius's work seems to have aimed at an audience that was already initiated in the basic principles of Latin grammar, including pupils from the higher classes who wanted to read the entire text for themselves (instead of the first two books which were read in class), teachers in other schools and mature scholars. Murmellius's knowledge of Latin and classical literature was naturally vastly superior to that of his medieval predecessors, but they would not have demurred to the basic assumption of the teaching of Murmellius and many of his contemporaries: 'studium duplex est: morum et litterarum'.

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DETLEV PÄTZOLD

IST TSCHIRNHAUS' *MEDICINA MENTIS* EIN ABLEGER VON SPINOZAS METHODOLOGIE?

Die Karriere von Graf Ehrenfried Walther von Tschirnhaus (1651–1708)¹ ist typisch für einen Mann des 17. Jahrhunderts, der nicht aus den damaligen Zentren der wissenschaftlichen Welt stammte, nicht im Umkreis von Amsterdam, London, Paris oder Venedig zu Hause war, um nur einige Orte zu nennen. Statt dessen stammte er aus dem östlichen Teil Mitteleuropas, einem Gebiet jenseits der Elbe in der Nähe von Görlitz. Er machte nicht nur die für adelige Söhne gängige Kavalierstour durch Westeuropa; diese absolvierte er zwar auch von 1674–1679, und sie führte ihn sogar bis Sizilien und Malta. Vielmehr hatte er sich schon einige Jahre früher den wissenschaftlich führenden Zentren Westeuropas zugewandt. Als Siebenzehnjähriger hatte er Görlitz den Rücken gekehrt und war westwärts gezogen, das im 17. Jahrhundert kleinstaatlich verwaltete und wissenschaftlich ziemlich uninteressante deutsche Gebiet zwischen Elbe und Rhein überspringend, um zunächst in den Niederlanden, wo er im Winter 1668 eintraf, an der Universität Leiden das Studium der Mathematik, Physik und Medizin aufzunehmen. Er kehrte im Frühjahr des Jahres 1674 kurz in seine Heimat zurück, um sodann, mit den nötigen finanziellen Mitteln ausgestattet, seine *grand tour* anzutreten. Sein Vater unterstützte diese große und kostspielige fünfjährige Reise offensichtlich auch deshalb, weil er selbst in seiner Jugend an italienischen Universitäten studiert hatte.

Tschirnhaus kehrte noch im Jahre 1674 zunächst wieder in die Niederlande zurück, begab sich im Mai 1675 nach London, wo er Anschluß an den Kreis der *Royal Society* erhielt und sodann mit einem Empfehlungsschreiben von deren Sekretär, Henry Oldenburg, weiter nach Paris zog. Hier lernte er den dort weilenden Christiaan Huygens und auch Leibniz kennen, der sich schon seit 1672 in einer völlig erfolglosen diplomatischen Mission dort aufhielt und, aus der Not eine Tugend machend, seine Zeit nutzte, um in Paris auf den Stand der damaligen

¹ Am ausführlichsten hat in neuerer Zeit Eduard Winter die Biographie von von Tschirnhaus dargestellt; vgl. E. Winter, *E. W. von Tschirnhaus (1651–1708). Ein Leben im Dienste des Akademiegedankens*, Berlin 1959; E. Winter, 'Der Bahnbrecher der deutschen Frühaufklärung', in: *E. W. von Tschirnhaus und die Frühaufklärung in Mittel- und Osteuropa*, E. Winter et al. (Hrsg.), Berlin 1960, 1–82.

Wissenschaft und Philosophie zu gelangen. Tschirnhaus blieb bis zum Herbst 1676 in Paris und war eine zeitlang Mathematiklehrer eines Sohnes des Ministers Colbert. Colbert machte ihn mit dem französischen Merkantilismus vertraut und erwies sich auch späterhin noch als sein Förderer, als Tschirnhaus 1682 wegen seiner Arbeiten zur Lösung algebraischer Gleichungen und zur Theorie der Kaustik zum Mitglied der *Académie Royale des Sciences*, die Colbert im Jahre 1666 mitgegründet hatte, ernannt wurde.² Im Herbst 1676 zog Tschirnhaus dann weiter auf seiner *grand tour*, die ihn über Lyon Richtung Italien und bis nach Malta führen sollte.

Wenn wir uns fragen, ob Tschirnhaus' Hauptwerk, seine *Medicina mentis*, möglicherweise ein 'Ableger' von Spinozas wissenschaftlicher und philosophischer Methodologie ist, dann handelt es sich bei dieser Fragestellung um ein Problem der *Rezeptionsgeschichte*. Natürlich wissen wir nie, wie ein Autor das Werk eines anderen gelesen hat. Es lassen sich immer nur *Spuren der Verarbeitung* des Denkens des anderen Autors im Werk des Rezipienten ausmachen. Allerdings gibt es darunter verschiedenartige literarische Formen, die auf spezifische Weise an die rezipierten Texte anschließen und so auf eine unmittelbarere Weise im eigenen Werk verarbeitet werden können. Auf sie muß man bei einem rezeptionsgeschichtlichen Ansatz deshalb gesondert eingehen. Eine dieser literarischen Formen ist der *Kommentar*, der seinerseits historisch sehr weit entfernt oder auch sehr nahe bei dem kommentierten Werk stehen kann. Historisch nahe ist beispielsweise Spinozas Kommentar zu den ersten zwei Büchern von Descartes' *Principia philosophiae*, aber noch näher ist beispielsweise das Manuskript von Leibniz, das den ersten Teil von Spinozas *Ethica* kommentiert, da Leibniz ein Jahr zuvor noch mit Spinoza selbst über Themen aus diesem erst posthum im Winter 1677/78 veröffentlichten Werk persönlich sprechen konnte.³

Die literarische Form des Kommentars besitzen wir leider im Falle von Tschirnhaus' Spinozarezeption nicht. Wir können allerdings hier auf eine andere literarische Form direkter Rezeption zurückgreifen, denn wir verfügen über einen Briefwechsel zwischen Tschirnhaus und Spinoza, in dem es sich um Verständnisfragen und kritische Anmerkungen des jungen Tschirnhaus zu den ihm bekannten Texten des Autors selbst dreht. Sehen

² Zur sogenannten 'Tschirnhaus- (T)-Transformation' und zur sogenannten 'Tschirnhaus-schen Kubik' vgl. O. Volk, 'E. W. v. Tschirnhaus als Mathematiker und Physiker', in: *E. W. von Tschirnhaus und die Frühaufklärung in Mittel- und Osteuropa*, E. Winter et al. (Hrsg.), 247-265, insbes. 255-264.

³ Den Versuch einer rezeptionsgeschichtlichen Darstellung der komplizierten Beziehung von Leibniz zu B. de Spinoza habe ich vorgestellt in: D. Pätzold, *Spinoza—Aufklärung—Idealismus. Die Substanz der Moderne*, Bern 1995, 51-93.

wir uns also zunächst die Jahre von 1674 bis 1676 etwas genauer an, denn in diese Zeit fällt Tschirnhaus' direkter Kontakt mit Spinoza.

Tschirnhaus als Briefpartner und Mittelsmann Spinozas

Tschirnhaus kam offensichtlich durch seinen Leidener Studienfreund Pieter van Gent mit Spinozas Denken und dem Meister selbst in Berührung.⁴ Er ist nicht nur der letzte, sondern wohl auch der philosophisch eindringlichste Briefpartner Spinozas. Signifikant ist außerdem, daß er, obwohl er selbst sehr kritische Bemerkungen zu Spinozas philosophischem Ansatz macht, einer der wenigen ist, die sich im 17. Jahrhundert ganz entschieden für Spinozas Denken gegenüber Kritikern einsetzten. Daß er dadurch in den Achtziger Jahren in Deutschland in eine gefährliche Debatte mit Christian Thomasius verstrickt wurde, in der er versuchte, seinen Hals aus der Schlinge zu ziehen, werden wir weiter unten noch anzusprechen haben.⁵ Die ersten zwei Briefe, die zwischen Tschirnhaus und Spinoza über Georg Hermann Schuller als Intermediär gewechselt wurden, datieren aus dem Winter 1674/75. Sie befassen sich mit methodologischen Fragen im engeren Sinne, aber auch mit metaphysischen Problemen wie der göttlichen und der menschlichen Willensfreiheit. Es ist nicht ganz deutlich, auf welchem Kenntnisstand der Werke Spinozas Tschirnhaus seine Fragen stellt. Was hat er gelesen und was kennt er nur vom Hörensagen? Die Fragen, die er im ersten Brief an Spinoza stellt, scheinen aus dem Umkreis von Spinozas 1663 veröffentlichten Descartes-Kommentar *Renati Des Cartes principiorum philosophiae pars I et II, more geometrico demonstratae per Benedictum de Spinoza* und insbesondere aus dem beigelegten Anhang, den *Cogitata metaphysica* zu erwachsen. Spinoza verweist in seinem ersten Antwortschreiben selbst hierauf.⁶ Von Spinozas unveröffentlichtem *Tractatus de intellectus emendatione*, der für methodologische Themen

⁴ Jean-Paul Wurtz gibt eine Reihe von Briefstellen an, die belegen, daß Tschirnhaus nicht nur mit B. de Spinoza korrespondierte, sondern auch eine oder mehrere persönliche Unterhaltungen mit ihm führte. Es sind die Briefe: von Tschirnhaus an B. de Spinoza vom 5.1.1675, ein undatiertes Brief von Tschirnhaus an Leibniz und ein Brief von Leibniz an den Herzog von Hannover aus dem Jahre 1678; vgl. J.-P. Wurtz, 'Tschirnhaus et Spinoza', *Theoria cum praxi. Zum Verhältnis von Theorie und Praxis im 17. und 18. Jahrhundert. Akten des III. Internationalen Leibniz-Kongresses, Hannover 12.-17.11.1977*, Bd. II, Wiesbaden 1981, 93-103, insbes. 93, 95.

⁵ Diese Kontroverse fand statt in den von Christian Thomasius herausgegebenen *Schertz- und ernsthafter, vernünftiger und einfältiger Gedanken über allerhand lustige und nützliche Bücher und Fragen, erster und zweiter Teil, Frankfurth und Leipzig 1688*. Erstausgaben dieser zwei Bände konnte ich einsehen in der Landesbibliothek Oldenburg (Lit. II, 2/372).

⁶ B. de Spinoza, *Briefwechsel*, Übersetzung und Anmerkungen von C. Gebhardt. Zweite, durch weitere Briefe ergänzte Auflage mit Einleitung und Bibliographie von M. Walther, Hamburg 1977, 239 (Brief 58 von B. de Spinoza an G. H. Schuller vom Herbst 1674).

natürlich einschlägig ist, scheint Tschirnhaus nur gehört zu haben,⁷ wohingegen er auf Spinozas ebenfalls zu Lebzeiten unveröffentlichtes Hauptwerk, die *Ethica*, und zwar auf Details aus der im zweiten Teil eingeschobenen Physik, anspielt: 'Wann werden wir Ihre Methode für die richtige Leitung der Vernunft bei der Ermittlung unbekannter Wahrheiten ebenso wie auch die Allgemeine Physik erhalten? Ich weiß, daß Sie schon längst große Fortschritte hierin gemacht haben. In bezug auf das erstere war es mir schon bekannt, und in betreff des letzteren zeigt es sich an den dem 2. Teil der Ethik beigegebenen Lehnsätzen, durch welche viele Schwierigkeiten in der Physik leicht sich lösen lassen'.⁸ Damit wird klar, worauf sich in diesen Jahren Tschirnhaus' Interesse vorwiegend richtet: es geht ihm um die Gewinnung einer wissenschaftlichen Methodologie, die als *ars judicandi* und als *ars inveniendi* zu sicheren und neuen Erkenntnissen in den Wissenschaften führen soll. Daß in diesem Zusammenhang auch metaphysische Fragen eine Rolle spielen oder doch zumindest nicht ausgeklammert werden, ist in seinem in den Niederlanden des 17. Jahrhunderts stark durch Descartes geprägten Umfeld nicht strittig. Und so verbindet er in seinem ersten Brief an Spinoza die Frage nach den Voraussetzungen wahrer Aussagen auch umstandslos mit dem Problem der Willensfreiheit. Im Anschluß an die ihm bekannten Schriften von Descartes (er nennt den *Discours de la méthode* und die *Meditationes de prima philosophia*) formuliert er eine eigene und ziemlich modern anmutende Regel von der Kontextgebundenheit wahrer Begriffe, die besagt, daß 'Wahrheit im Begriffe nicht immer absolut wahr ist, sondern nur unter Voraussetzung dessen, was im Verstand als wahr angenommen wird. Diese Regel ist so allgemeingültig, daß sie bei allen Menschen, selbst Wahnsinnige und Schlafende nicht ausgenommen, gilt'.⁹ Daraus ergibt sich für ihn nun aber das Problem, das er Spinoza vorlegt, nämlich daß bei Annahme eines uneingeschränkten Vernunftgebrauchs, also dann, wenn wir absolut über unsere Vernunft verfügen und die Dinge außer uns darauf keine Macht ausüben, angesichts der aufgestellten Regel jede beliebige

⁷ Den *Tractatus de intellectus emendatione* hat er nach eigenem Bekunden erst viel später, nachdem er die *Opera Posthuma* B. de Spinozas erhalten hatte, zur Kenntnis genommen: 'Hernach habe lange Zeit erst hierauff diesen Tractat nach dem Tode des Autoris in die Hände bekommen', E. W. von Tschirnhaus, *Eilfertiges Bedencken wieder die Objectiones, so im Mense Martio Schertz- und Ernsthafter Gedancken über den Tractat Medicinae Mentis enthalten*, in: Chr. Thomasius, *Freimütige, lustige und ernsthafte, jedoch vernunftmässige Gedanken oder Monatsgespräche über allerhand, fürnehmlich aber neue Bücher*, Bd. I: Januar-Juni 1688, repr. Athenäum, Frankfurt/M. 1972, 775.

⁸ B. de Spinoza, *Briefwechsel*, 239 (Brief 59 von E. W. Tschirnhaus an B. de Spinoza vom 5. Januar 1675).

⁹ B. de Spinoza, *Briefwechsel*, 232 (Brief 57 von E. W. Tschirnhaus an B. de Spinoza vom 8. Oktober 1674).

kontextgebundene Aussage wahr werden müßte. Dies würde z.B. auch gelten für entgegengesetzte Positionen in der Frage der Willensfreiheit, wie sie durch Descartes einerseits und Spinoza andererseits vertreten werden: 'Beide scheinen mir Wahres zu sagen, sowohl der, der dafür, als der, welcher dagegen eintritt, je nachdem nämlich einer die Freiheit begreift. Frei nennt Descartes, was von keiner Ursache gezwungen wird, Sie hingegen, was von keiner Ursache zu etwas bestimmt wird. Ich bin also mit Ihnen der Ansicht, daß wir in allen Dingen von einer bestimmten Ursache zu etwas bestimmt werden und demnach keine Willensfreiheit besitzen, hingegen bin ich mit Descartes der Meinung, daß wir in gewissen Dingen (die ich gleich angeben werde) in keiner Beziehung gezwungen werden und somit Willensfreiheit haben'.¹⁰ Und diese Ausnahme von 'allen Dingen'(!) ist für Tschirnhaus nun, korrekt formuliert als Konditional, genau unsere Vernunft: 'Wenn ich über meine Vernunft verfügen kann, ob ich dann ganz frei, d.h. absolut davon Gebrauch machen kann? Darauf antworte ich: ja'.¹¹ Einmal abgesehen von den metaphysischen Aspekten der Frage nach der Freiheit des Willens, geht es also bezogen auf die wissenschaftliche Methodologie um die Frage, ob wir vollständig freie Hand haben bei der Aufstellung der Axiome und Definitionen wissenschaftlicher Theorien, aus denen dann entsprechend dem jeweilig so festgelegten Theorierahmen wahre Aussagen zu gewinnen wären. Spinoza geht jedoch in seinem ersten Antwortschreiben nur auf die ontologischen, nicht die methodologischen Aspekte des Problems ein und äußert sich nur ganz unumwunden zur Willensfreiheit im Sinne seiner nezessitaristischen Position. Er sagt dort: Es 'gilt von jedem besondern Dinge, wie zusammengesetzt und zu Vielfachem fähig man es sich auch denken mag, daß nämlich jedes Ding von einer äußeren Ursache bestimmt wird, auf eine gewisse bestimmte Weise zu existieren und zu wirken'.¹² Es ist daher vielleicht kein Zufall, wenn sich Tschirnhaus in seinem zweiten Brief an Spinoza nun ganz auf den methodologischen Aspekt und dabei insbesondere auf dessen Definitionslehre konzentriert, denn das Thema der Willensfreiheit hatte ja für ihn nur exemplarische Funktion.

Hinsichtlich der Quelle, auf die sich hier Tschirnhaus' Frage bezieht, haben wir diesenfalls mehr Deutlichkeit. Grundlage ist ein Gespräch, das er mittlerweile mit Spinoza selbst führen konnte und in dem dieser ihm offensichtlich etwas aus seinem *Tractatus de intellectus emendatione* mitgeteilt hatte. Allerdings wird es nicht allzuviel gewesen sein, denn

¹⁰ Ebd., 233.

¹¹ Ebd., 233.

¹² B. de Spinoza, *Briefwechsel*, 236 (Brief 58 von B. de Spinoza an G. H. Schuller vom Herbst 1674).

Tschirnhaus fragt nach einigen Details bezüglich Spinozas Unterscheidung zwischen bestimmten Typen von Ideen. 'Als ich bei Ihnen war, gaben Sie mir die Methode an, deren Sie sich bei der Erforschung noch nicht bekannter Wahrheiten bedienen. (...). Deshalb wünsche ich, daß Sie mir die wahre Definition der adäquaten, wahren, falschen, fingierten und zweifelhaften Idee mitteilen'.¹³ Hinsichtlich der Frage nach der angemessensten Methode des Definierens, die zu wahren Ideen der Dinge führen soll, gibt Tschirnhaus selbst den Weg an, der die logische Grund-Folge-Beziehung als eine kausale Ordnung begreift, die von den Folgen bzw. Wirkungen zurück auf die Gründe bzw. Ursachen schließt, um schließlich bei einer letzten nicht weiter begründbaren oder verursachten Idee zu stoppen. Er schreibt, er habe sich gefragt, 'welches die Ursache dieser Idee oder dieses Begriffes sei. Hatte ich sie erkannt, so habe ich von neuem gefragt, welches wiederum die Ursache dieses Begriffes sei. Hatte ich sie erkannt, so habe ich die Forschung nach den Ursachen der Ursachen der Ideen fortgesetzt, bis ich auf eine Ursache gestoßen war, von der ich eine andere Ursache nicht finden konnte, als daß eben unter allen möglichen Ideen, die ich in mir habe, auch diese eine gehört'.¹⁴ Damit folgt Tschirnhaus eigentlich einem Verfahren, das schon Thomas Hobbes im Methodenkapitel seines Werks *De corpore* (1655) vorgeschlagen hatte.¹⁵ Spinoza gibt Tschirnhaus als Antwort seine Lehre von der kausalen oder realen Definition als derjenigen, die gegenüber allen möglichen Nominaldefinitionen für ihn, wie übrigens auch schon für Hobbes, die einzig wahre wissenschaftliche Definition sei. Das Paradebeispiel ist die Definition eines Kreises durch Angabe seiner Konstruktion: er entsteht, indem man eine gerade Linie um einen ihrer Endpunkte rotieren läßt.¹⁶ Spinoza unterläßt aber nicht, und dies im Unterschied zu Hobbes, darauf hinzuweisen, daß die beste Methode diejenige sei, zunächst die Definition von demjenigen Seienden aufzustellen, das die Ursache von allen Dingen (also letztlich die Definition Gottes) ist. Diesen Zusammenhang hatte er schon früh in einem

¹³ B. de Spinoza, *Briefwechsel*, 240 (Brief 59 von E. W. Tschirnhaus an B. de Spinoza vom 5. Januar 1675). Im *Tractatus* war B. de Spinoza im 'ersten Teil der Methode' ausführlich auf 'die fingierte Idee', 'die falsche Idee' und 'die zweifelhafte Idee' eingegangen; vgl. B. de Spinoza, *Tractatus de intellectus emendatione*, hrsg. lat.-dt. neu übersetzt, mit Einleitung und Anmerkungen versehen von W. Bartuschat, Hamburg 1993, 43-75.

¹⁴ B. de Spinoza, *Briefwechsel*, 240 (Brief 59 von E. W. Tschirnhaus an B. de Spinoza vom 5. Januar 1675).

¹⁵ Vgl. Th. Hobbes, *De corpore*, übersetzt, mit einer Einleitung und mit textkritischen Annotationen versehen und hrsg. von K. Schuhmann, Hamburg 1997, 75, 77 ff.

¹⁶ Vgl. B. de Spinoza, *Briefwechsel*, 242 (Brief 60 von B. de Spinoza an E. W. Tschirnhaus vom Anfang 1675). Vgl. auch: B. de Spinoza, *Tractatus de intellectus emendatione*, 85 f. Ebenso schon: Th. Hobbes, *De corpore*, 19.

Brief an Simon de Vries¹⁷ dargelegt, und darin bestand für ihn ja auch die Quintessenz aus seinem *Tractatus de intellectus emendatione*,¹⁸ die damit die Überleitung zu seinem Hauptwerk der *Ethica* und die Begründung für ihren axiomatisch-deduktiven Aufbau darstellte. So gibt er Tschirnhaus denn auch den Unterschied zwischen einer Nominal- und einer Realdefinition bezüglich der Gottesidee als Grundlage seines deduktiven Systemaufbaus: 'Ebenso auch, wenn ich Gott definiere als das im höchsten Grade vollkommene Wesen, eine Definition, die die bewirkende Ursache nicht zum Ausdruck bringt (denn ich kenne sowohl eine innere als eine äußere bewirkende Ursache), so werde ich daraus nicht alle Eigenschaften Gottes erschließen können; wenn ich dagegen Gott definiere als ein Wesen usw. (siehe Definition 6 im 1. Teil der Ethik). (...) Das, worauf es nach meiner Ansicht in erster Linie ankommt, ist, eine solche Idee ausfindig zu machen, aus der sich, wie gesagt, alles herleiten läßt'.¹⁹ Diesen Zusammenhang von einem systemkonstitutiven Gottesbegriff und wissenschaftlicher Methode wird, wie wir weiter unten noch sehen werden, Tschirnhaus für seine *Medicina mentis* nicht übernehmen. Daß er im übrigen in seinem zweiten Brief auch gezielt nach Spinozas 'wahrer Definition der Bewegung' fragt, legt die Vermutung nahe, daß Hobbes' Methodenlehre im Hintergrund stehen könnte, denn Hobbes hatte ja 'Bewegung' zur ersten Ursache und zum grundlegenden Axiom für alle weiteren Universalien erklärt.²⁰

Der folgende Brief von Tschirnhaus stammt aus der Zeit seines Londoner Aufenthalts, wohin er im Mai 1675 gereist war. Tschirnhaus' eigenem Brief

¹⁷ B. de Spinoza, *Briefwechsel*, 37 ff. (Brief 9 von B. de Spinoza an S. de Vries vom Februar-März 1663).

¹⁸ Vgl. B. de Spinoza, *Tractatus de intellectus emendatione*, 33 f., 41, 87 f.

¹⁹ B. de Spinoza, *Briefwechsel*, 242 f. (Brief 60 von B. de Spinoza an E. W. Tschirnhaus vom Anfang 1675).

²⁰ Vgl. Th. Hobbes, *De corpore*, 79. Ob Tschirnhaus zu diesem Zeitpunkt Hobbes' Schrift tatsächlich kannte, konnte ich bisher nicht klären. Ich konnte den Auktionskatalog der Hinterlassenschaft von Tschirnhaus noch nicht einsehen: *Catagolus und Specification unterschiedener gebundener und ungebundener Bücher, auch mathematischer und anderer Instrumenten und Curiosorum aus Verlassenschaft des Hrn. Rathes von Tschirnhaus auf Kießlingswalde etc., welche allhier in Görlitz(...) aufn 23. August 1723 (...) per modum auctionis feilgeboten und Meistbietendem gegen Bezahlung überlassen werden sollen*. In der *Medicina mentis* bezieht sich Tschirnhaus zweimal auf Hobbes, allerdings nur negativ auf seine Arbeit zur Quadratur des Kreises und seine Einwände zu Descartes' *Meditationes de prima philosophia*, sowie positiv auf seine Staatslehre; vgl. E. W. von Tschirnhaus, *Medicina mentis sive artis inveniendi praecepta generalia. Editio nova Lipsiae 1695*, erstmalig ins Deutsche übersetzt und kommentiert von J. Hausleiter, Leipzig 1963, 190 (174), 259 (260). Wenn nicht anders angegeben, zitiere ich im folgenden diese deutsche Übersetzung als *Medicina mentis* und gebe in Klammern jeweils die Paginierung der lateinischen Originalausgabe, die als Repr. erhältlich ist: E. W. von Tschirnhaus, *Medicina Mentis et Corporis. Editio nova Lipsiae 1695*, mit einem Vorwort von W. Risse, repr. Olms, Hildesheim 1964.

aus dem August geht ein Brief von Schuller aus dem Juli vorher, in dem er von Tschirnhaus' Vermittlungsversuchen berichtet und einige Spinozas *Ethica* betreffende Fragen übermittelt, auf die Tschirnhaus in seinem eigenen Schreiben allerdings selbst zurückkommt. Zunächst eine kurze Bemerkung zu Tschirnhaus' Vermittlertätigkeit in London. Schon Anfang der Sechziger Jahre hatte Spinoza eine Korrespondenz mit Henry Oldenburg und, vermittelt über ihn, mit Robert Boyle unterhalten. Es war in diesen Jahren Henry Oldenburg, der Spinoza ermutigt hatte, seine Philosophie zu veröffentlichen.²¹ Durch den englisch-niederländischen Krieg brach die Korrespondenz Ende 1665 ab. Und als dann im Jahre 1770 Spinozas *Tractatus theologico-politicus* erschien, scheinen Oldenburg und seine Freunde entsetzt über dessen radikale Thesen gewesen zu sein. Ganz offensichtlich gelang es Tschirnhaus während seiner Begegnungen mit Oldenburg und Boyle in London, Spinozas Philosophie bei ihnen wieder in einem günstigeren Licht erscheinen zu lassen, d.h. er betätigte sich wirklich als Mittelsmann für Spinozas Denken. Schuller schreibt hierüber in dem genannten Brief: 'Übrigens berichtet er (Tschirnhaus, D.P.), Herr Boyle und Oldenburgh hätten eine sehr wunderliche Vorstellung von Ihrer Person gehabt; er hat ihnen diese Vorstellung nicht bloß genommen, sondern ihnen auch Gründe an die Hand gegeben, unter deren Einfluß sie nicht nur wieder sehr würdig und günstig von Ihnen denken, sondern auch den Theol.-politischen Trakt. sehr hoch schätzen, wovon ich Ihnen, Ihrer Weisung entsprechend, Mitteilung zu machen nicht gewagt habe'.²² Und in der Tat, schon ab Anfang Juni entstand zwischen Oldenburg und Spinoza ein neuer Briefwechsel, der sich vorwiegend um den *Tractatus theologico-politicus* drehte. Oldenburg sollte zwar bis zum Schluß seine Bedenken aufrecht erhalten, aber immerhin entwickelte sich ein wenn auch kontroverser, so doch fairer Dialog mit Spinoza.

Methodologisch interessant in Tschirnhaus' Londoner Brief ist vor allem seine Frage nach dem in Spinozas *Ethica* angelegten Parallelismus zwischen den einzelnen Attributen bzw. Modi, d.h. denen des Denkens und der Ausdehnung. Mit Spinoza nimmt er an, daß die eine Welt auf unendlich verschiedene Weisen ausgedrückt wird entsprechend der unendlichen Anzahl göttlicher Attribute und deren Modifikationen. 'Daraus scheint zu folgen, daß die Modification, die meinen Geist ausmacht, und jene Modification, die meinen Körper ausdrückt, wenn es auch ein und dieselbe Modification ist, dennoch auf unendliche Weisen ausgedrückt ist, in einer

²¹ Vgl. B. de Spinoza, *Briefwechsel*, 32 (Brief 7 von H. Oldenburg an B. de Spinoza vom Juli 1662).

²² B. de Spinoza, *Briefwechsel*, 248 (Brief 63 von G. H. Schuller an B. de Spinoza vom 25. Juli 1675).

Weise durch das Denken, in einer anderen durch die Ausdehnung, in einer dritten durch ein mir unbekanntes Attribut Gottes, und so fort ins Unendliche, weil es unendliche Attribute Gottes gibt und weil die Ordnung und Verknüpfung der Modificationen in allen dieselbe zu sein scheint'.²³ Tschirnhaus stellt sich die Frage, warum unser Geist als anderen Modus nur die Ausdehnung begreift und keine weiteren Modi. Diese Frage ist jedoch offensichtlich inkonsequent, denn wenn man Spinozas Parallelismus von Attributen und Modi, wie er schon in der 2. Definition des 1. Teils seiner *Ethica* gelehrt wird, ernstnimmt, dann müßte die Frage eigentlich lauten, wieso unser Geist überhaupt nicht nur sich selbst, also den Modus des Denkens, mittels der Reflexion (der *idea ideae*) begreift. Schon das Begreifen eines zweiten Modus, der der körperlichen Ausdehnung (die *idea corporis*), ist das Problem und nicht erst das Begreifen einer darüber noch hinausgehenden Anzahl weiterer Modi. Anders gesagt: das Problem ist der Übergang von der ontologischen zur epistemischen Ebene, oder vom Ausdrücken (*exprimere*) zum Begreifen (*concipere*). Aber da Tschirnhaus diese konsequentere Frage nicht aufwirft, hat es Spinoza leicht mit seiner Antwort, indem er auf seinen Parallelismus verweisen kann: wir müssen uns jeweils in den Modi ausdrücken, in denen wir uns selbst befinden, nur Gott kennt die Dinge in ihren unendlich vielen Modifikationen, d.h. so, wie sie an sich sind (*ut in se sunt*).²⁴

Die letzten Briefe von Tschirnhaus stammen aus Paris. Wiederum ist es Schuller, der Spinoza zunächst von Tschirnhaus' Reise und Aktivitäten berichtet.²⁵ Auch in Paris betätigte Tschirnhaus sich als Botschafter der Philosophie Spinozas. Diesenfalls ist es Leibniz, den er, entgegen aller im Freundeskreis Spinozas beachteter Vorsicht, auf den neuesten Stand der Philosophie Spinozas zu bringen und ihn dafür einzunehmen versucht.²⁶ Leibniz bleibt in vielen Punkten skeptisch, und auch nach dem Tode Spinozas, als Tschirnhaus und Leibniz noch zuweilen über Spinozas

²³ B. de Spinoza, *Briefwechsel*, 251 (Brief 65 von E. W. Tschirnhaus an B. de Spinoza vom 12. August 1675).

²⁴ Vgl. B. de Spinoza, *Briefwechsel*, 252 (Brief 66 von B. de Spinoza an E. W. von Tschirnhaus vom 18. August 1675) und: B. de Spinoza, *Ethica more geometrico demonstrata*. In: B. de Spinoza, *Opera*, lateinisch und deutsch hrsg. von K. Blumenstock, Bd. II, Darmstadt 1967, 169 f.

²⁵ Vgl. B. de Spinoza, *Briefwechsel*, 270 ff. (Brief 70 von G. H. Schuller an B. de Spinoza vom 14. November 1675) und B. de Spinozas Antwortbrief, ebd., 274 f. (Brief 72 von B. de Spinoza an G. H. Schuller vom 18. November 1675).

²⁶ Zur Frage, was an Manuskripten Tschirnhaus in Paris mit sich führte vgl. G. Friedmann, *Leibniz et Spinoza*, Paris 1946, 62 ff.; J.- P. Wurtz, 'Tschirnhaus et Spinoza', 93 f.; P. Steenbakkers, *Spinoza's Ethica from Manuscript to Print. Studies on Text, Form and Related Topics*, Utrecht 1994, 38 f.

Philosophie in ihrem Briefwechsel diskutieren, ist es immer nur Tschirnhaus, der gute Worte für Spinoza findet.²⁷

In diesen letzten Briefen, die von Paris aus zwischen Tschirnhaus und Spinoza gewechselt werden, stehen deutlich wiederum methodologische Fragen in bezug auf physikalische und mathematische Probleme im Vordergrund. Referenzpunkt bleiben aber weiterhin die ersten zwei Bücher von Spinozas *Ethica*, nebst einem Brief älteren Datums von Spinoza an Ludwig Meyer vom 20. April 1663, in dem er seinen Begriff des Unendlichen differenziert hatte. Interessant sind hierbei vor allem die kritischen Bemerkungen, die Tschirnhaus gegenüber jedem Projekt einer rein axiomatisch aufgebauten und deduktiv verfahrenen Wissenschaft macht. 'Zunächst kann ich sehr schwer begreifen, wie man a priori die Existenz von Körpern demonstriert, die Bewegung und Gestalt haben, da doch in der Ausdehnung, schlechthin betrachtet, sich nichts Derartiges zeigt'.²⁸ Damit steht ein Kernpunkt der Physik Descartes' zur Debatte. Aus dem Begriff der Ausdehnung kann, wenn er physikalisch als ruhende Masse interpretiert wird, wegen des Trägheitsprinzips nicht eine Vielheit sich bewogender Körper a priori bewiesen werden. Descartes nahm bekanntlich als Annahme eine von Gott ursprünglich mitgeteilte und von ihm erhaltene Bewegungsquantität zur Hilfe. Wie Tschirnhaus richtig vermutet, kann Spinoza dem nicht zustimmen, und er grenzt sich in seiner Antwort dementsprechend scharf gegen Descartes ab.²⁹ Dadurch entsteht für Tschirnhaus die Frage, wie Spinoza seinerseits ohne die cartesianische Annahme aus seinem Begriff des unendlichen Attributs der Ausdehnung eine Erklärung gelingen könne, denn 'das hat nun weiter zur Folge, daß ich nicht einsehen kann, in welcher Weise aus einem Attribut für sich allein betrachtet, z.B. aus der unendlichen Ausdehnung, die Verschiedenheit der Körper hervorgehen kann'.³⁰ Obwohl Tschirnhaus' Kritik zunächst im Bereich der Bewegungslehre physikalischer Körper ansetzt, scheint er seine Überlegungen auch allgemeiner auf den Bereich der Methodologie ausdehnen zu wollen, indem er Beispiele aus dem Definitionsverfahren mathematischer Gegenstände hinzuzieht: 'Die Gründe jedoch, aus denen ich gerade dies wissen möchte, sind folgende: in der Mathematik habe ich oft die Beobachtung gemacht, daß man aus jedem Ding an sich betrachtet, d.h.

²⁷ Vgl. seinen Briefwechsel mit Tschirnhaus in: G. W. Leibniz, *Sämtliche Schriften und Briefe*, hrsg. von der Akademie der Wissenschaften Berlin. Dritte Reihe, Bd. III und IV, Berlin 1991, 1995; vgl. auch D. Pätzold, *Spinoza—Aufklärung—Idealismus*, 55 ff.

²⁸ B. de Spinoza, *Briefwechsel*, 296 (Brief 80 von E. W. Tschirnhaus an B. de Spinoza vom 2. Mai 1676).

²⁹ Vgl. B. de Spinoza, *Briefwechsel*, 297 (Brief 81 von B. de Spinoza an E. W. Tschirnhaus vom 5. Mai 1676).

³⁰ B. de Spinoza, *Briefwechsel*, 299 (Brief 82 von E. W. Tschirnhaus an B. de Spinoza vom 23. Juni 1676).

aus der Definition eines jeden Dinges wenigstens eine Eigenschaft herzuleiten vermag; möchte man aber mehrere Eigenschaften haben, so ist es nötig, das definierte Ding auf andere Dinge zu beziehen; alsdann ergeben sich aus der Verbindung dieser Definitionen neue Eigenschaften'.³¹

Im ersten Punkt mag Spinozas Antwort enttäuschend für Tschirnhaus gewesen sein. Er vertröstet ihn auf einen späteren Zeitpunkt, wo er zeigen werde, wie anders denn als durch die Ausdehnung allein die Bewegung der Körper und die Verschiedenheit der Dinge a priori bewiesen werden könnte.³² Aber die neuen wissenschaftlichen Antworten kamen dann bekanntlich für die physikalische Bewegungslehre erst mit Newtons Gravitationstheorie und mit der Kant-Laplace'schen Kosmogonie ins Blickfeld, sowie für die Verschiedenheit der Dinge im umfassenderen Sinne noch viel später mit Darwins Evolutionstheorie.

In dem anderen, allgemein methodologischen Punkt hat Spinoza jedoch Tschirnhaus vielleicht einen entscheidenden Anstoß gegeben. Er macht einen grundlegenden Unterschied zwischen den sehr einfachen Dingen, wie geometrischen Figuren als reinen Gedankendingen (*entia rationis*) und den wirklichen Dingen (*entia realia*). Bei letzteren könne aus ihrer angemessenen Definition mehr als nur eine Eigenschaft erschlossen werden. Er erläutert dies mit seinem Gottesbegriff, deutet jedoch an, daß auch andere Beispiele möglich wären.³³ Jedenfalls ist es für Tschirnhaus' späteres eigenes Hauptwerk signifikant, daß er versucht, die deduktive Methode mit der induktiven Methode zu komplementieren, daß er neben apriorischen Aspekten auch aposteriorische gleichrangig gelten läßt. Aber damit bin ich schon beim zweiten Teil dieses Artikels.

Tschirnhaus' Medicina mentis und Spinozas Methodologie

Tschirnhaus' Hauptwerk, die *Medicina mentis sive tentamen genuinae logicae, in qua disseritur de methodo detegendi incognitas veritates* erschien erstmals 1686 (nachdatiert auf 1687) in Amsterdam.³⁴ Der nicht flüssige lateinische Stil von Tschirnhaus wurde auf seine Veranlassung von

³¹ B. de Spinoza, *Briefwechsel*, 298 f. (Brief 82 von E. W. Tschirnhaus an B. de Spinoza vom 23. Juni 1676).

³² Im physikalischen Intermezzo im 2. Teil der *Ethica* wird die Bewegung ja nur axiomatisch eingeführt: '1. Axiom. Alle Körper sind entweder in Bewegung oder in Ruhe', B. de Spinoza, *Ethica*, 185.

³³ Vgl. B. de Spinoza, *Briefwechsel*, 300 (Brief 83 von B. de Spinoza an E. W. Tschirnhaus vom 15. Juli 1676).

³⁴ Es enthält übrigens keinen namentlichen Hinweis auf B. de Spinoza. Ein Exemplar dieser Erstausgabe konnte ich einsehen in der Landesbibliothek Oldenburg (Philos. I/3 214).

seinem Freund Pieter van Gent für den Druck nachgebessert.³⁵ Wie aus Briefen an Leibniz vom 27. Mai 1682 und an Christiaan Huygens vom 11. September 1682 sowie vom 30. August 1683 zu ersehen ist, war die Planung seines Werkes jedoch schon viel früher begonnen und teilweise auch schon ausgeführt worden.³⁶ Eine Neuausgabe (*Editio nova*)³⁷ erschien im Jahre 1695 in Leipzig, nachdem in den Jahren 1688 und 1689 eine heftige Kontroverse mit Christian Thomasius unter anderem über seinen angeblich unchristlichen, spinozistischen Gottesbegriff stattgefunden hatte.

Der Titel seines Hauptwerks, '*Medicina mentis*', ist vielleicht mit Spinozas Denken allein schon deshalb eng verknüpft, weil Spinoza selbst in seinem frühen *Tractatus de intellectus emendatione*³⁸ und insbesondere auch in den zwei letzten Büchern seiner *Ethica* bis in die Wortwahl den thematischen Hintergrund für Tschirnhaus' Projekt vorgab.³⁹ Andererseits haben derartige Titel auch eine lange Tradition. Um nur drei Beispiele zu nennen: schon Cicero sagt '*est profecto animi medicina philosophia*' (*Tusculanes* III, 1,6) und ein halbes Jahrtausend später weist Boethius' ganze Schrift *Consolatio philosophiae* in diese Richtung; nochmals etwa fünfhundert Jahre später bezeichnete der berühmte arabische Arzt und Philosoph Avicenna seine Philosophie, wie der Titel seiner umfangreichen philosophischen Enzyklopädie, die Logik, Physik, Mathematik und Metaphysik umfaßte, anzeigt, ausdrücklich als *Das Buch der Genesung der*

³⁵ Vgl. J.- P. Wurtz, 'Über einige offene oder strittige, die *Medicina mentis* von Tschirnhaus betreffende Fragen', *Studia Leibnitiana* 20 (1988), 190-203, insbes. 204-209; vgl. P. Steenbakkers, *Spinoza's Ethica from Manuscript to Print*, 15, 24, 47-48. Die *Medicina corporis* wurde dagegen aus dem deutschsprachigen Manuskript durch van Gent ins Lateinische übersetzt.

³⁶ Vgl. die *Introduction* von J.- P. Wurtz zu seiner französischen Edition der zweiten Ausgabe der *Medicina mentis*: E. W. von Tschirnhaus, *Médecine de l'esprit ou préceptes généraux de l'art de découvrir*, introduction, traduction, notes et appendices par J.- P. Wurtz, Paris 1980, 11-13.

³⁷ Jean-Paul Wurtz bietet in seiner oben genannten französischen Übersetzung der *Editio nova* sämtliche Abweichungen gegenüber der ersten Ausgabe aus dem Jahre 1687 (1686); im folgenden zitiere ich, weil sie leicht erreichbar ist, die Varianten aus dieser französischen Ausgabe als *Médecine de l'esprit*.

³⁸ 'Vor allem aber ist ein Mittel zu ersinnen, den Verstand zu heilen (modus medendi intellectus) und ihn, soweit zu Anfang [der Untersuchung] geht, zu reinigen, damit er die Dinge gedeihlich, ohne Irrtum und so trefflich wie möglich, begreift'; B. de Spinoza, *Tractatus de intellectus emendatione*, 15 f.; vgl. auch: V. P. Zubov, 'Die cartesianische Physik und Tschirnhaus', in: E. W. von Tschirnhaus und die Frühaufklärung in Mittel- und Osteuropa, E. Winter et al. (Hrsg.), 270, 277 f., 284.

³⁹ Aus dem Februar des Jahres 1676 datiert eine Notiz von Leibniz, die sich auf ein Gespräch mit Tschirnhaus über B. de Spinoza bezieht. In dieser Notiz werden die beiden letzten Teile von B. de Spinozas *Ethica* mit den Titeln der späteren Werke von Tschirnhaus umschrieben: 'Mons. Tschirnhaus m'a conté beaucoup de choses du livre de Ms. De Spinoza. (...) Le livre de Spinoza sera de Deo, mente, beatitudine seu perfecti hominis idea, de Medicina Mentis, de medicina corporis.' G. W. Leibniz, *Sämtliche Schriften und Briefe*, Sechste Reihe, Bd. III, Berlin 1980, 384.

Seele.⁴⁰ Die Tatsache, daß Tschirnhaus dem ersten Teil seines Hauptwerks auch ein kürzeres zweites Buch an die Seite stellt, das den Titel *Medicina corporis seu cogitationes admodum probabiles de conservanda sanitate* (Amsterdam 1686) trägt, kann auch ein Hinweis darauf sein, daß er sich vielleicht eher in dieser letzteren Tradition sehen wollte.

Aber einmal abgesehen von diesem zweiten kleinen Buch, was haben wir von seinem Hauptwerk oder 'Traktat', wie Tschirnhaus zuweilen sein erstes großes Buch nennt, das uns im Titel die Heilung des Geistes verspricht, zu erwarten? Ein kurzer Blick auf Spinozas thematisch entsprechende Werke kann uns Übereinstimmungen und Unterschiede vor Augen führen. Spinozas *Tractatus de intellectus emendatione* und seine *Ethica* bildeten insofern eine Einheit, als er im *Tractatus* die Methode entwickelte, die uns zu wahren und adäquaten Erkenntnissen befähigen sollte und die ihn dazu führte, als höchstes Gut dasjenige auszuzeichnen, was uns die Gewinnung der Einsicht (*cognitio*) in die Einheit, die der Geist (*mens*) mit der Natur im Ganzen (*tota Natura*) hat, erlangen lasse.⁴¹ Die Einheit selbst jedoch, die unser Geist mit der Natur im Ganzen bildet, war für Spinoza allerdings nicht nur eine Frage der Methodologie, sondern auch eine der darauf abgestimmten Ontologie einschließlich der dazu passenden Definition Gottes und des Beweises seiner Existenz. Denn gemäß seiner Formel: *Deus sive Natura* war für ihn die Natur im Ganzen, einschließlich unseres menschlichen Geistes, ohne eine entsprechende Konzeption Gottes (zu verstehen als genitivus subjectivus und objektivus!) als der immanten (nicht transzendenten) Ursache der Natur, also als Einheit von *natura naturans* und *natura naturata* nicht zu haben.⁴² Folgerichtig enthält sein vorwiegend methodologischen Fragen gewidmeter *Tractatus* wiederholt den Hinweis, daß die vollkommene Methode erfordere, so schnell als möglich einen adäquaten Begriff Gottes zu gewinnen.⁴³ Und so stehen gegen Ende des Fragment gebliebenen *Tractatus* auch Überlegungen, welchen Anforderungen die rechte Definition Gottes im Unterschied zum Definitionsverfahren bei endlichen Dingen genügen muß.⁴⁴ Die *Ethica* zeigt dann in ihrem ersten Teil, wie dieses Programm in der Darstellungsweise der euklidisch-geometrischen Methode zu effektuierten ist. Er liefert gleichsam die 'Onto-Theo-Logie' (wenn man es mit diesem unschönen

⁴⁰ Eine deutsche Übersetzung der darin enthaltenen Metaphysik hat Max Horten angefertigt: M. Horten, *Das Buch der Genesung der Seele. Eine philosophische Enzyklopädie Avicennas. XIII. Teil: Die Metaphysik*, Halle 1907-1909.

⁴¹ Vgl. B. de Spinoza, *Tractatus de intellectus emendatione*, 15.

⁴² Vgl. B. de Spinoza, *Ethica*, 383, 393; 131; 133.

⁴³ Vgl. B. de Spinoza, *Tractatus de intellectus emendatione*, 35, 41, 83.

⁴⁴ Vgl. ebd., 87 f.; vgl. auch B. de Spinoza, *Briefwechsel*, 242 f. (Brief 60 von B. de Spinoza an E. W. Tschirnhaus vom Anfang 1675).

Kunstwort Heideggers umschreiben will), welche die Grundlage der Einheit bildet, die unser Geist mit der Natur im Ganzen hat.

Tschirnhaus nennt in der Darlegung seines Programms im 'Vorwort an den Leser'⁴⁵ zwar auch an erster Stelle Gott als die Quelle unseres höchsten Gutes, welches eben unbestritten darin besteht, 'daß unser Intellekt von allen Gütern, die uns die göttliche Gnade auf natürlichem Wege zugestanden hat, in jeder Beziehung das vornehmste ist'.⁴⁶ Dabei läßt er es dann aber auch bewenden, denn er will in seinem Buch 'nur' einen Weg zeigen, 'durch den unser Intellekt aufs beste vervollkommnet wird, soweit es durch natürliche Mittel geschehen kann'.⁴⁷ Er habe daher, wie er selbst sagt, in seinem Buch nicht die vollständige Philosophie zusammengefaßt, sondern nur die 'Erste Philosophie (*prima philosophia*)' geben wollen, was eigentlich in klassischer Terminologie der alte aristotelische Ausdruck für die später sogenannte 'Metaphysik' war. Tschirnhaus will sich allerdings von der 'Schulmeta-physik' abgrenzen, denn 'weil von sehr vielen in ihr nur höchst unnütze Spekulationen angestellt werden, pflegt sie den meisten Gelehrten sehr verhaßt zu sein'.⁴⁸ Es ist daher auch nicht überraschend, daß er seine Auffassung von 'Erster Philosophie' gleichsetzt mit 'Logik',⁴⁹ was ihn übrigens wiederum in große Nähe zu Hobbes bringt, der ja auch den ersten Teil seiner in *De corpore* entwickelten Philosophiekonzeption als Logik bezeichnet hatte. Zusätzlich nimmt er in seine Definition von 'Erster Philosophie' allerdings auch noch ihre Nützlichkeit im Sinne von teils praktischer Philosophie mit hinein. 'So wisse, daß ich in dieser meiner Ersten Philosophie alles das behandeln werde, was ein Mensch, der die ernste Absicht hat, sich die Weisheit zu erwerben, zu allererst kennen muß. Ferner, obgleich es jedenfalls wahr ist, daß besonders das Nützliche nur am Ende der Philosophie gelehrt werden kann, wirst du doch in der Tat beim Lesen dieses Buches erfahren, daß dir schon gerade zu Anfang dieser Philosophie überaus Nützliches geboten wird'.⁵⁰ Und er nennt als Beispiele die selbständige Wahrheitsfindung, die Beherrschung der Affekte, die Erhaltung der Gesundheit und die kluge Kindererziehung. Dies sind nun wiederum Formulierungen, die ganz stark an eine Stelle in Spinozas *Tractatus* erinnern.⁵¹

⁴⁵ Das Vorwort der ersten Ausgabe ist nur ganz kurz und ist stilisiert als das von 'einem Freund des Autors an den Leser'; der Hinweis auf die Vernunft als Geschenk Gottes fehlt aber auch hier nicht; vgl. *Médecine de l'esprit*, 37.

⁴⁶ *Medicina mentis*, 38.

⁴⁷ *Medicina mentis*, 39.

⁴⁸ *Medicina mentis*, 42.

⁴⁹ Vgl. *Medicina mentis*, 43.

⁵⁰ *Medicina mentis*, 42 f.

⁵¹ Vgl. B. de Spinoza, *Tractatus de intellectus emendatione*, 15 f.

Tschirnhaus ist des weiteren der Überzeugung, daß die Philosophie mittlerweile zwei historisch frühere Stadien überwunden habe, wo es nur den *historalis philosophus* und den *verbalis philosophus* gegeben habe, und jetzt die Zeit reif sei für den *realis philosophus*. Die 'Sachphilosophie' als die höchste Stufe der Erkenntnis zu nehmen, ist wohl eine Einstellung, die Tschirnhaus von Spinoza vermittelt bekommen hat, insofern er ihn in seinem letzten Brief, wie wir oben gesehen hatten, darauf hinwies, daß bei der Definition wirklicher Dinge (*entia realia*) der Komplexionsgrad so zunehme, daß notwendigerweise nicht nur analytisch jeweils eine Eigenschaft erschlossen werden müsse, wie dies bei den ganz einfachen oder Gedankendingen (*entia rationis*) geschehe. Diesen Hinweis nimmt Tschirnhaus hier nun so auf, daß man mit dem menschlichen Intellekt die Interrelationen mehrerer Dinge dergestalt ins Blickfeld nehmen müsse, so daß aus ihnen mittels synthetischer Verfahren eine Reihe von interdependenten und neuen Eigenschaften erschließbar werden. Es geht ihm also um eine Erfindungskunst (*ars inveniendi*): 'so gibt es in gleicher Weise [wie in der *Analysis speciosa*, D.P.] eine allgemeine Wissenschaft (*generalis scientia*), mit deren Hilfe jeder beliebige, der mit ihr gehörig ausgerüstet ist, nicht allein alles Verborgene, was es in der Mathematik gibt, sondern auch alles Unbekannte, soweit es unter den Intellekt fällt, durch eine sichere und feststehende Methode mit Gewißheit ans Licht bringen kann. Und diese Wissenschaft oder, wenn man lieber will, diese Kunst des Entdeckens (*ars inveniendi*) ist selbst die echte Philosophie'.⁵² Leibniz werden bei diesen Worten die Ohren geklungen haben, denn es handelt sich um nichts anderes als sein früheres ehrgeiziges und letztlich gescheitertes Programm, das sein jüngerer Landsmann hier nochmals so selbstsicher verkündet. Tschirnhaus nennt jedoch in diesem Zusammenhang nicht Leibniz, sondern eine andere Galerie berühmter Namen: Viète, Descartes, Arnauld, Malebranche, Mariotte.⁵³ Aber auch Spinoza wird namentlich nicht genannt. Daß Tschirnhaus nicht nur aus den von ihm erwähnten, sondern aus vielerlei Quellen schöpft, wird deutlich, wenn man einen Blick auf die von ihm als gegen jeden Skeptizismus immun geglaubten vier Prinzipien wirft, die er seinem ganzen Unternehmen zugrunde legt. Die Zusammenstellung dieser Prinzipien mutet sehr eklektisch an, aber für ihn ist ihnen gemeinsam, daß sie alle schon durch die bloße Erfahrung jederzeit als evident gelten können. Das erste besagt: 'Ich bin mir verschiedener Dinge bewußt; dies ist das erste und allgemeine Prinzip unserer ganzen Erkenntnis'.⁵⁴ Diese Formulierung erinnert an Leibniz, der es als Erfahrungsprinzip gleichberechtigt neben den

⁵² *Medicina mentis*, 40.

⁵³ Vgl. *Medicina mentis*, 41.

⁵⁴ *Medicina mentis*, 44.

Identitätssatz als Prinzip des Verstandes stellte.⁵⁵ Das von Tschirnhaus an vierter Stelle genannte Prinzip, das näherhin die verschiedenen Quellen unserer Erfahrung angibt, nämlich die äußeren Sinne, innere Vorstellungsbilder und Leidenschaften,⁵⁶ könnte sowohl von Descartes als auch von Locke beeinflusst sein, um nur zwei sehr unterschiedliche Positionen aus Tschirnhaus' näherem historischen Kontext zu nennen. Das zweite und dritte Prinzip scheint demgegenüber eher auf Spinoza zurückführbar zu sein. Das dritte als Grundlage jeder Morallehre besagt, daß 'ich von einigen Dingen gut, von anderen jedoch schlecht berührt werde' und erinnert an eine entsprechende Formulierung in Spinozas *Tractatus*, die ja auch in seiner Affektenlehre in der *Ethica* ihre Spuren hinterläßt.⁵⁷ Das vierte Prinzip, welches als Kriterium für Wahres und Falsches die Denkbarkeit (logische Kohärenz) einer Vorstellung bzw. ihre Undenkbarkeit angibt, zeigt eine große Verwandtschaft mit Spinozas berühmten Diktum, daß die Wahrheit Norm ihrer selbst und des Falschen sei.⁵⁸

Aber sehen wir uns nun den dreiteiligen Haupttext der *Medicina mentis* unter einigen für unser—auf die Beziehung zu Spinoza zugespitztes—Thema ausgewählten Gesichtspunkten etwas genauer an. Ich beginne mit den wenigen Bemerkungen, die Tschirnhaus zum Gottesbegriff macht. Da er seine *scientia generalis* oder *ars inveniendi* als die Methode anpreist, mittels derer wir ständig neue Wahrheiten entdecken können, und da auf der anderen Seite Gott derjenige ist, der schon im Besitz aller Wahrheiten ist und alles mit einem Blick durchschaut, so steht Tschirnhaus nicht an festzustellen, 'daß wir uns durch eine solche Wissenschaft mit Gott gleichsam unterreden, von dem doch einzig und allein jede Wahrheit gewissermaßen als von dem Quell der Wahrheit selbst ihren Ursprung herleitet, und daß es uns daher auch auf diese natürliche Weise gestattet wird, durch ein bestimmtes Verfahren Gott zu erkennen'.⁵⁹ Dieses bestimmte Verfahren besteht, wie man sich denken kann, in nichts anderem als der konsequenten Ausübung der Methode der Wahrheitsfindung, so daß es zu einer immer weitergehenden Angleichung mit Gott kommen kann. Zwar gibt es Stellen bei Spinoza, die dem nahe kommen, aber Spinoza ging

⁵⁵ 'Duo illa prima principia: unum rationis: *Identica sunt vera, et contradictionem implicantia sunt falsa*, alterum experientiae: *quod varia à me percipiuntur*'; G. W. Leibniz, *Opusculs et fragments inédits*, éd. par L. Couturat, Paris 1903, repr. Olms, Hildesheim 1966, 183.

⁵⁶ Vgl. *Medicina mentis*, 45.

⁵⁷ *Medicina mentis*, 44; vgl. B. de Spinoza, *Tractatus de intellectus emendatione*, 7. Zu Spinozas Affektenlehre vgl. W. Bartuschat, *Spinozas Theorie des Menschen*, Hamburg 1992, 142 ff.

⁵⁸ Vgl. *Medicina mentis*, 44 f.; vgl. B. de Spinoza, *Tractatus de intellectus emendatione*, 63; B. de Spinoza, *Ethica*, 231.

⁵⁹ *Medicina mentis*, 65 (23).

doch nie so weit zu behaupten, dies führe dazu, daß 'unsere Natur gleichsam in eine übermenschliche' verwandelt würde.⁶⁰ An Sätzen wie diesen war auch die oben schon angedeutete Kontroverse mit Christian Thomasius entbrannt, und er hatte versucht, Tschirnhaus unter anderem einen spinozistischen Gottesbegriff zu unterstellen.⁶¹ Dieser reagierte in demselben Publikationsorgan mit der Replik *Eilfertiges Bedencken wieder die Objectiones*, in der er sich den Angriffen zu widersetzen versuchte und ebenfalls in seinem allerdings unpublizierten *Anhang An Mein sogenantes Eilfertiges bedencken*, wo er nicht nur die Zweifel an seiner Rechtgläubigkeit auszuräumen versuchte, sondern sich auch explizit von Spinozas Philosophie abgrenzte.⁶² Aber dies nützte wenig, wie aus der Reaktion von Thomasius auf sein *Eilfertiges Bedencken* zu ersehen ist.⁶³

In seltsamem Kontrast sowohl zu diesen Angriffen von Thomasius als auch zu Tschirnhaus' eigenem überschwenglichem Erkenntnisoptimismus steht allerdings die Tatsache, daß er im Hinblick auf den von ihm verwendeten Gottesbegriff sich sehr traditionell und zurückhaltend verhält, indem er als Definition Gottes—und zwar gleichermaßen in der ersten wie in der zweiten Auflage—den Begriff des *ens perfectissimum* wählt.⁶⁴ Spinoza hatte diese Definition in seinem *Tractatus* zwar selbst häufiger verwendet, aber er hatte, wie wir oben schon gesehen haben, Tschirnhaus in seinem Brief von Anfang 1675 (Brief 60) ausdrücklich auf den Unterschied zwischen der unzureichenden Definition als *ens perfectissimum* und der angemessenen Definition als *ens absolute infinitum* bzw. als *substantia absolute infinita* hingewiesen, so wie sie dann in der 6. Definition und im 8., 11. und 13. Lehrsatz des ersten Teils der *Ethica* eingesetzt wurde. Darüber

⁶⁰ *Medicina mentis*, 65 (23/24). Als Vergleich siehe B. de Spinoza, *Ethica*, 253. B. de Spinoza unterstreicht dort nur die klassische Teilhabe-Lehre, nicht die These von der Transmutation unserer Natur ins Übermenschliche (*natura supra-humana*). Nebenbei bemerkt: Die Wurzeln Nietzsches führen also offensichtlich nach Niederschlesien und Gott sei Dank nicht in die Niederlande!

⁶¹ Vgl. Chr. Thomasius, *Monatsgespräche*, Bd. I, 431 f: 'So wäre auch wider das Christenthum, was von der Erhöhung der menschlichen Natur zu der göttlichen p 19. angeführet werde, und wäre zufoererst nöthig, daß der Herr T. seine conceptus von GOtt ein wenig deutlicher erklärete'. Zu den vermeintlichen Übereinstimmungen mit B. de Spinozas Auffassungen vgl. ebd., 421 ff. Die Gesamtrezension der *Medicina mentis* findet sich auf den Seiten 354-362 und 386-442.

⁶² Vgl. E. W. von Tschirnhaus, *Eilfertiges Bedencken*, 746-792; E. W. von Tschirnhaus, *Anhang An Mein so genantes Eilfertiges bedencken worinnen, die im Monath Juno der Schertz und Ernsthaften gedanken enthaltene objectiones beantwortet werden*, Einführung, Transkription und Anmerkungen von J.- P. Wurtz, *Studia Leibnitiana* 15 (1983), 149-204, vgl. insbes. 50, 59, 60, 63, 83. Ausführlicher wird diese Kontroverse diskutiert bei J.- P. Wurtz, 'Tschirnhaus und die B. de Spinozabeschuldigung: die Polemik mit Christian Thomasius', *Studia Leibnitiana* 13 (1981), 61-75, insbes. 70-75; und bei R. Otto, *Studien zur Spinozarezeption in Deutschland im 18. Jahrhundert*, Bern 1994, 84-91.

⁶³ Vgl. Chr. Thomasius, *Monatsgespräche*, Bd. I, 793-850, vgl. insbes. 820, 829.

⁶⁴ Vgl. *Medicina mentis*, 65 (24).

hinaus hatte Spinoza Hinweise darauf gegeben, wie wir als endliche Wesen zu dem Begriff eines unendlichen Wesens gelangen.⁶⁵ Daß Tschirnhaus um diese Auffassungen sehr wohl wußte, zeigt sich in seinem Briefwechsel mit Leibniz und auch noch später mit Christian Wolff, worauf Jean-Paul Wurtz in einer Anmerkung zu seiner französischen Übersetzung der *Medicina mentis* aufmerksam gemacht hat.⁶⁶ Wenn er trotzdem in der *Medicina mentis* von Spinoza in diesem Punkte abweicht, so zweifle ich, ob die Angst, in zu große Nähe zu Spinoza zu geraten, der Grund hierfür war, denn Tschirnhaus hätte sich für den Begriff Gottes als *substantia infinita* ja unter anderem auch auf Descartes' Formulierungen in der dritten seiner *Meditationes de prima philosophia* berufen können. Vielleicht muß man einfach die Annahme wagen, daß ihm die systematische Bedeutung von Spinozas Gotteslehre für die von ihm selbst angestrebte Methodenlehre nicht so wichtig war.

Auch die wenigen anderen Stellen, wo er sich auf den Gottesbegriff einläßt, zeigen—mit einer bedeutenden Ausnahme—in dieselbe Richtung. So umschreibt er Gott in der ersten und auch in der zweiten Auflage sehr traditionell als 'unendlichen Geist', 'weisestes Wesen' und spricht unter Bezugnahme auf Robert Boyle von Gottes 'Weisheit, Macht und Güte'.⁶⁷ Anders als Spinoza, für den der apriorische Gottesbeweis eine zentrale Stelle einnimmt, weist Tschirnhaus nur einmal am Rande auf einen aposteriorischen Beweis der Existenz Gottes hin.⁶⁸ Interessant sind allerdings einige Textstellen gegen Ende seines Werkes, die einen anderen Tenor haben. Er gibt dort seine hohe Wertschätzung der Physik als Leitwissenschaft zu erkennen, und zwar mit einer Begründung, die an Spinozas Determinismus anknüpft: 'Diese Wissenschaft [die Physik, D.P.] aber ist als einzige von ihnen wahrhaft göttlich. Denn in ihr werden Gesetze entwickelt, die allein von Gott seinen Werken eingegeben sind, Gesetze, nach denen alles unwandelbar wirkt und die auf keine Weise von unserem Intellekt, sondern von Gott, der realiter existiert, abhängen, so daß die Betrachtung der Werke der Physik nichts anderes ist als die Betrachtung der Wirksamkeit Gottes'.⁶⁹ Zwar scheint er diese Bemerkung kurz darauf dadurch abzuschwächen, daß er sie im Sinne des Occasionalismus (von Malebranche) interpretiert,⁷⁰ aber gut eine Seite später kommt sein überschwenglicher Erkenntnisoptimismus wieder voll zur Geltung in einer

⁶⁵ Vgl. B. de Spinoza, *Ethica*, 227 f., 237 f., 249.

⁶⁶ Vgl. *Médecine de l'esprit*, 263.

⁶⁷ Vgl. *Medicina mentis*, 89 (56); 212 (200); 279 (286).

⁶⁸ Vgl. *Medicina mentis*, 212 (200).

⁶⁹ *Medicina mentis*, 277 (283 f.).

⁷⁰ Vgl. *Medicina mentis*, 278 (285); vgl. auch die Anmerkung von J.- P. Wurtz in: *Médecine de l'esprit*, 294.

Formulierung, die einen indirekten Hinweis auf Spinoza enthält, indem hier erstmals dessen Gottesbegriff und die dazugehörige Attributenlehre in Erscheinung tritt. 'Denn wenn die Behandlung aller allgemeinen (Probleme) dieser Wissenschaft [der Physik, D.P.] gut vollendet ist, wird uns nicht nur die Kenntnis unseres Geistes und seiner Unsterblichkeit, sondern auch diejenige Gottes selbst, seiner realen und notwendigen Existenz und seiner unendlich vollkommenen Eigenschaften, soweit sie durch das natürliche Licht erlangt werden kann, viel deutlicher und leichter'.⁷¹ Als Kronzeugen für diese Aussichten gibt er jedoch wiederum nicht Spinoza an, sondern bezieht sich auf eine Bemerkung, die Descartes am Anfang der fünften seiner *Meditationes de prima philosophia* gegeben hatte und in der er vieles, was er noch über die Attribute Gottes zu sagen habe, zunächst beiseite stellen müsse.⁷² Daß Descartes für diese Dinge nicht der rechte Kronzeuge sein konnte, wird spätestens dann deutlich, wenn man in seinen späteren *Principia philosophiae* liest,⁷³ wie wenig ihm an der weiteren Erforschung der Eigenschaften Gottes in seiner Philosophie gelegen war.

Ein zweiter Hauptgesichtspunkt, unter dem Tschirnhaus' Werk in Bezug zu Spinoza gesehen werden kann, betrifft die philosophische Methodologie im engeren Sinne. Hierbei soll zumindest kurz noch zweierlei zur Sprache kommen. Erstens die Objektbereiche, auf die die jeweilige philosophische Methodologie ausgerichtet und zugeschnitten wird; zweitens die Frage nach der angemessenen Definitionslehre, die die Wahrheitsfrage und das Verhältnis von apriorischen und aposteriorischen Verfahren mit einschließt.

Ein erster die praktische Philosophie betreffender Gegenstandsbereich seiner Methodologie ist, wie bei Spinoza auch, der Bereich der Ethik in einem allerdings noch wenig systematisch verstandenen Sinne. Es geht hierbei mehr um eine Affekten- und Tugendlehre zum Zwecke einer 'gesunden' individuellen Lebensführung, die ganz im Dienste der Förderung einer wissenschaftlichen Welteinstellung unter den Primat der Rationalität gestellt wird. Diesen Intentionen vergleichbar waren aber auch schon Descartes' Regeln zu einer 'provisorischen' Moral im dritten Teil seines *Discours de la méthode* aus dem Jahre 1637. Tschirnhaus, der hierbei in der Tradition von Descartes und Spinoza steht, gibt drei schlichte Bedingungen an, die eine solche ethische Grundeinstellung gewährleisten sollen. Die erste besteht darin, niemandem Schaden zufügen zu wollen: 'Beobachtet habe ich nämlich in mir von früher Jugend an einmal das Verlangen, niemandem zu schaden, ja vielmehr jedem Gutes zu wünschen, und so viel an mir lag, zu

⁷¹ *Medicina mentis*, 279 (286 f.).

⁷² Vgl. R. Descartes, *Meditationes de prima philosophia*, lateinisch-deutsch hrsg. von L. Gäbe und H. G. Zekl, Hamburg 1977, 115.

⁷³ Vgl. R. Descartes, *Principia philosophiae*, übers. und mit Anmerkungen versehen von A. Buchenau, Hamburg 1992, 10 (pars I, § 28).

tun'.⁷⁴ Es handelt sich also um das Prinzip der Nächstenliebe, das auch Spinoza in seinem *Tractatus theologico-politicus* als den einzigen Zweck der Heiligen Schrift bestimmt hatte.⁷⁵ Die zweite Bedingung, die Descartes' vierter Regel seiner provisorischen Moral⁷⁶ und ebenso Spinozas Grundeinstellung entspricht, besteht in einer unbegrenzten wissenschaftlichen Neugier, dem 'bedeutenden Eifer, immer Neues und Wissenswertes hinzuzulernen'.⁷⁷ Drittens schließlich wird das Bemühen vorausgesetzt, 'das Leben so glücklich wie nur möglich zu gestalten', wobei, wie die Erläuterungen zeigen,⁷⁸ es sich für Tschirnhaus vor allem um die individuelle Autonomie handelt, anders als bei Spinozas Bestreben, ein kollektives Glück zu erlangen.⁷⁹ Tschirnhaus war sich wohl im klaren darüber, daß er in seiner Heimat nicht die gleichen Voraussetzungen finden würde, wie Spinoza in den Niederlanden für seine in diesem Punkte weitergehenden Ziele. Ganz übereinstimmend mit Spinozas viertem und fünftem Teil seiner *Ethica* ist dann aber wieder Tschirnhaus' allgemeiner Leitrat, 'daß nichts einer glücklichen Lebensführung mehr im Wege ist, als die Leidenschaften des Gemütes'.⁸⁰ All diese Bemerkungen haben, wie gesagt, keinen systematischen Status, sondern bilden in gewissem Sinne nur die Prolegomena zu seiner Methodologie und ihrem vornehmlichsten Gegenstandsbezug.

Denn es ist unübersehbar, daß Tschirnhaus durch sein ganzes Buch hin seine methodologischen Überlegungen im Kontext mathematischer Probleme diskutiert, und so sind die meisten Anwendungsfälle und Lösungsvorschläge aus diesem Gegenstandsbereich entnommen. Mit wieviel Erfolg er dies unternimmt, will ich hier nicht besprechen,⁸¹ sondern nur anmerken, daß die prominente Rolle der Mathematik in Kontrast steht zu der, wie wir oben schon sehen konnten, von Tschirnhaus selbst so stark

⁷⁴ *Medicina mentis*, 48 f. (1).

⁷⁵ 'Was ferner jeder tun muß, um Gott zu gehorchen, lehrt die Schrift an vielen Stellen aufs klarste: das ganze Gesetz besteht in dem einen, nämlich in der Liebe gegen den Nächsten'; 'Fordert der Glaube doch ausdrücklich nicht wahre Dogmen, sondern nur solche, die zum Gehorsam nötig sind, indem sie nämlich die Seele in der Nächstenliebe bestärken, und bloß in Ansehung dessen ist jeder in Gott (um mit Johannes zu reden) und Gott in ihm'. B. de Spinoza, *Tractatus theologico-politicus*, in B. de Spinoza, *Opera*, lateinisch und deutsch hrsg. von G. Gawlick und F. Niewöhner, Bd. I, Darmstadt 1979, 429 f.; 435 (c. XIV).

⁷⁶ Vgl. R. Descartes, *Discours de la methode*, französisch-deutsch übers. und hrsg. von L. Gäbe, Hamburg 1969, 45 f.

⁷⁷ *Medicina mentis*, 49 (1).

⁷⁸ *Medicina mentis*, 49 (1), vgl. ebd. 50 ff. (4 ff.).

⁷⁹ 'D.h.: zu meinem Glücke gehört es auch, mich zu bemühen, daß viele andere dasselbe begreifen wie ich, damit ihr Verstand und ihr Begehren mit meinem Verstand und meinem Begehren gänzlich übereinstimmen', B. de Spinoza, *Tractatus de intellectus emendatione*, 15.

⁸⁰ *Medicina mentis*, 52 (6); vgl. ebd. 60 ff. (17 ff.).

⁸¹ Schon ihm wohlgesonnene, fachkompetente Zeitgenossen wie Huygens und Leibniz sparten nicht mit Kritik.

hervorgehobenen Bedeutung der Physik als eigentlicher Leitwissenschaft. Bei Spinoza war die Gewichtung eher anders herum verteilt. Neben der Anwendung des *mos geometricus* als Darstellungsmethode seiner Philosophie äußert sich Spinoza in seinem Hauptwerk kaum zu mathematischen Fragen. Statt dessen gibt er dort sehr wohl einen, wenn auch nur im Ansatz entwickelten, Versuch einer axiomatischen Grundlegung der Physik, d.h. soweit sie klassische Mechanik im vornewtonianischen Stande der Entwicklung war.⁸²

Hinsichtlich unseres zweiten noch zu besprechenden Punktes gibt es dagegen zunächst wieder viel Übereinkunft zwischen Tschirnhaus und Spinoza bezüglich der Definitionslehre. Fast wörtlich folgt er Spinozas oben schon erwähnter Bevorzugung und Umschreibung kausaler Definitionen bei endlichen Dingen: 'Zweitens ist offenbar, daß jede Definition einer einzelnen Sache immer die erste Art der Bildung dieser Sache in sich schließen muß, eine Bildungsart, die ich die *Generation* einer Sache nennen werde. Denn eine Sache in Wahrheit begreifen ist nichts anderes als die Tätigkeit oder der gedankliche Prozeß ihrer Bildung (*formatio*); und daher ist das, was von einer Sache begriffen wird, nichts anderes als die erste Art ihrer Bildung oder, wenn man lieber will, ihre Erzeugung (*generatio*).'⁸³

Allerdings weichen Spinoza und Tschirnhaus in der Frage nach den Wahrheitskriterien der auf solchen wissenschaftlichen Definitionen basieren-den Aussagen partiell voneinander ab. Während Spinoza methodologisch gesehen weitgehend einem kohärenztheoretischen Wahrheitsbegriff verpflichtet ist, den er erst über den ontologischen Gottesbegriff so absichert, daß kohärente Aussagen in im Sinne der Korrespondenz wahre Aussagen überführbar sind, scheint dies Tschirnhaus nicht mehr sinnvoll zu sein, und so komplementiert er seinen Wahrheitsbegriff mit einem ganz anderen Kriterium. Daß für Spinoza Wahrheit Norm ihrer selbst und des Falschen ist,⁸⁴ so daß an jeder Aussage selbst ablesbar ist, ob sie in sich kohärent und damit wahrheitsfähig oder aber in sich widersprüchlich und damit falsch ist, wurde für ihn dadurch gewährleistet, daß Denken und Ausdehnung zwei vollständig parallel geschaltete Attribute der einen göttlichen Substanz sind. Damit setzt sich für ihn dieser Parallelismus auch auf der Ebene der Modifikationen dieser Attribute fort, so daß jeder unserer endlichen Gedanken, soweit er rein auf

⁸² Vgl. B. de Spinoza, *Ethica*, 185-193.

⁸³ *Medicina mentis*, 98 (56). Daß B. de Spinoza hierbei für Tschirnhaus die erste und wichtigste Quelle war und nicht Hobbes und Leibniz, hat Jean-Paul Wurtz überzeugend gezeigt; vgl. J.- P. Wurtz, 'Über einige offene oder strittige, die *Medicina mentis* von Tschirnhaus betreffende Fragen', 201 ff.

⁸⁴ Diesen Satz übernimmt Tschirnhaus ohne Umschweife, aber letztlich nicht die bei B. de Spinoza dahinter stehende Begründung; vgl. *Medicina mentis*, 96 (65).

der Ebene der *ratio* als *idea ideae* gefaßt wird und nicht getrübt wird durch eine unklare *idea corporis* der *imaginatio*, kohärent ist innerhalb der Ordnung des Denkens. Und so definiert er auch zu Beginn des zweiten Teils seiner *Ethica* zunächst die Adäquatheit einer Idee ganz bewußt rein kohärenztheoretisch 'Unter adäquater Vorstellung (*idea adaequata*) verstehe ich diejenige Vorstellung, welche, insofern sie an sich, ohne Bezug auf den Gegenstand, betrachtet wird, alle Eigenschaften oder inneren Merkmale einer wahren Vorstellung hat. Erläuterung. Ich sage innere, um das auszuschließen, was äusserlich ist, nämlich das Uebereinstimmen der Vorstellung mit ihrem Gegenstande'.⁸⁵ Daß darüber hinaus diese Kohärenz unseres rein-rationalen Denkens zugleich das Wesen der extramentalen Ordnung der Dinge wiedergibt und damit auch zu wahren Aussagen im korrespondenztheoretischen Sinne führt, liegt an dem durch Gottes Attribute sich in ihren Modi fortsetzenden Parallelismus von Denken und Ausdehnung: 'Die Ordnung und Verknüpfung der Vorstellungen (*idearum*) ist dieselbe (*idem est*), wie die Ordnung und Verknüpfung der Dinge (*rerum*).'⁸⁶

Da nun offensichtlich für Tschirnhaus der spinozistische Gottesbegriff keine entscheidende Rolle mehr spielt und damit nicht mehr diesen systematischen Status als Garant für die Übereinstimmung der Ordnung des Denkens mit der Seinsordnung haben kann, ist es nicht verwunderlich, daß Tschirnhaus sich nach einem anderen Kriterium für die korrespondenztheoretische Absicherung wahrer Aussagen umsehen muß.⁸⁷ Er findet es auf der Ebene der empirischen Bestätigung unserer Aussagen über die extramentalen Gegenstände unserer Theorien. Für den Wechsel von der apriorisch-deduktiven Verfahrensweise des menschlichen Intellekts zum aposteriorisch-induktiven Verfahren der Bestätigung seiner Aussagen durch die Empirie muß Tschirnhaus ein zweites menschliches Erkenntnisvermögen bemühen, das von Spinoza gerade diskreditiert worden war: die auf der sinnlichen Wahrnehmung beruhende *imaginatio*. Man könnte fast sagen, daß die Pointe seines ganzen methodologischen Ansatzes darin besteht, diesen Gegensatz zwischen *ratio* und *imaginatio* zu überbrücken,⁸⁸ und weite Teile seines Buches sind denn auch diesem Programm gewidmet. Somit kann für ihn bei der Erkenntnis partikularer Dinge durchaus zweigleisig verfahren werden: 'Weiter braucht nicht immer

⁸⁵ B. de Spinoza, *Ethica*, 163.

⁸⁶ B. de Spinoza, *Ethica*, 169.

⁸⁷ Nur für den Beginn des Philosophierens teilt er noch B. de Spinozas Ansicht: 'Besonders muß bemerkt werden, daß zu Beginn des Philosophierens auf keine Weise nachgeforscht zu werden braucht, ob die Wahrheit in meinem Begriffe übereinstimmt mit den außer mir existierenden Dingen'; *Medicina mentis*, 86 (52).

⁸⁸ Ausdrücklich sagt er dies z.B. *Medicina mentis*, 198 (182), 201 f. (186 f.), 205 (191).

die partikuläre Natur irgendeines Dinges vorher erkannt werden, sondern nur diejenige, die mehreren anderen gemeinsam ist, wenn nämlich dieselbe Wirkung nicht schlechthin nur das verlangt, was so verbunden wird, sondern auch anderes zuläßt; und dann wird das ausgewählt, dessen Natur entweder dem Intellekt einfacher oder den Sinnen evidenter erscheint. Auch hier braucht nicht immer die Natur von allem, was auf diese Weise verbunden wird, *a priori* erkannt zu werden, sofern diese durch die klare Erfahrung *a posteriori* bekannt ist. Hieraus entstehen die Hypothesen, die einige zum Beweis ihrer Sätze anwenden'.⁸⁹ Gegen Ende seines Werkes faßt er dieses Programm nochmals anläßlich der in der Physik zu befolgenden Methode kernig zusammen: 'Denn was mich betrifft, so verstehe ich hier nichts anderes unter der Physik als die Wissenschaft des Universums, die durch die genaue Methode der Mathematiker *a priori* bewiesen und durch die evidentesten Erfahrungen, welche eben die Imagination überzeugen, *a posteriori* bestätigt wurde'.⁹⁰ Wie man sieht, schließt dieser Ansatz für ihn ein, daß die axiomatisch-deduktive Methode ihre entscheidende Schlüsselrolle behält. Er stellt sich dabei eine (nicht logisch) zirkuläre Begründungsstruktur vor, in der aposteriorische Elemente, 'erste Erfahrungen' am Anfang stehen, die aber sodann durch apriorische Ableitungen begründet werden. 'Es ist nämlich meine Ansicht, daß man zwar zunächst *a posteriori* beginnen soll, daß dann aber beim Fortschreiten alles nur *a priori* abzuleiten und das einzelne überall durch evidente Erfahrungen (*per evidentes experientias*) zu bestätigen ist; und das dies so lange fortgesetzt werden muß, bis wir wiederum zu den ersten Erfahrungen, die wir am Anfang herangezogen hatten, durch die Ordnung selbst geleitet, zurückkehren und so der ganze Kreis der Philosophie ohne Zirkel (nämlich den, den die Logiker mißbilligen) vollendet ist'.⁹¹ Das Problem besteht allerdings in dem in diesem ganzen Prozeß ebenfalls eine Rolle spielenden zweiten aposteriorischen Element, nämlich den 'evidenten Erfahrungen'. Denn grundsätzlich mißtraut Tschirnhaus ebenso wie Spinoza eigentlich der auf Wahrnehmungen beruhenden *imaginatio*: 'Wenn also vom Intellekt her keine Irrtümer entstehen und es nur zwei Fähigkeiten gibt, nämlich die des Begreifens, die Intellekt genannt wird, und die des Wahrnehmens, die als Imagination bezeichnet wird, wie bereits angezeigt wurde, dann ist es notwendig, daß die Irrtümer ihre Entstehung von der Imagination

⁸⁹ *Medicina mentis*, 153 f. (130); vgl. auch ebd. 113 f. (86).

⁹⁰ *Medicina mentis*, 274 f. (280).

⁹¹ *Medicina mentis*, 282 (290). V. P. Zubov übersetzt hier *per evidentes experientias* sehr frei mit 'durch anschauliche Experimente'; vgl. V. P. Zubov, 'Die cartesianische Physik und Tschirnhaus', 274. Wo Tschirnhaus wirklich Experimente meint, sagt er es mit dem richtigen Ausdruck: *experimenta*! Vgl. z.B. ebd. 113 (85), 114 (86, 87), 115 (88).

herleiten'.⁹² Er äußert allerdings die Hoffnung, daß sich die *imaginatio* auf die Gesetze des Intellekts zurückführen ließen derart, daß bei ihrer Anwendung ein Irrtum nahezu auszuschließen sei.⁹³ Aber dann wäre diese gänzlich vom Intellekt regulierte *imaginatio* vollständig von der anderen menschlichen Fähigkeit, der zur Wahrnehmung, abgeschnitten und ihre erwünschte unabhängige Rolle bei der empirischen Bestätigung der durch apriorische Ableitungen gewonnenen Aussagen nicht mehr gut aufrecht zu erhalten.

Es wäre gewiß reizvoll, sich abschließend die Frage zu stellen, ob die Position Spinozas oder die von Tschirnhaus den Hauptpreis verdiente. Das hieße im Kontext der hier analysierten Thematik und Texte, ob im 17. Jahrhundert eine philosophische Methodologie zum Behufe des Fortschritts in den Wissenschaften mit einer passenden Gotteslehre unterbaut werden müsse und konsistent zu machen sei, oder aber besser ohne eine solche auskommen sollte und könnte. Einmal ganz abgesehen vom hermeneutischen Dilemma solcherart Fragestellungen, will ich mir hierüber kein Urteil anmaßen, da es jedenfalls bedeutend mehr erfordert, als was ich hier zu leisten vermochte. So darf ich erleichtert in diesem Punkt mein Fazit britisch kurz und sportlich halten: Zwei prima Männer, zwei prima Meinungen!

⁹² *Medicina mentis*, 182 (165). Diese Schwierigkeiten hat erneut Jean-Paul Wurtz diskutiert in: J.-P. Wurtz, 'Über einige offene oder strittige, die *Medicina mentis* von Tschirnhaus betreffende Fragen', 199 ff. Er kommt zu der Einschätzung, daß wir bei Tschirnhaus noch keine Lösung im Sinne der modernen experimentellen Methode antreffen. Andererseits läßt sich eine positivere Lesart verteidigen, wenn man einen deutlichen Unterschied macht zwischen dem, was Tschirnhaus ganz allgemein als auf der sinnlichen Wahrnehmung beruhende *imaginatio* nennt, und was er mit dem Ausdruck 'evidente Erfahrungen' meint. Aber genau dies ist aus seinem Text kaum zu ermitteln. Er nennt zwar vier erste, evidente Erfahrungen, aber diese repräsentieren in erster Linie die Grundlagen seiner Erkenntnistheorie oder seiner rationalen Psychologie und verweisen nicht auf die Rolle der experimentellen Methode. Er nennt 1. die im cartesischen cogito-Argument ausgedrückte Erfahrung des eigenen Bewußtseins, 2. die Erfahrung, daß uns einiges gut und anderes schlecht berührt, 3. die Erfahrung, daß einiges für uns begreifbar und anderes nicht begreifbar ist, 4. die Erfahrung, daß wir durch äußere Dinge mittels der Sinneswahrnehmung, innere Vorstellungsbilder und Leidenschaften affiziert werden; vgl. *Medicina mentis*, 282 ff. (291 ff.).

⁹³ Vgl. *Medicina mentis*, 89 (56), 198 (183), 228 (221).

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HAN VAN RULER

‘SOMETHING, I KNOW NOT WHAT’.
THE CONCEPT OF SUBSTANCE IN EARLY MODERN THOUGHT

It is the philosopher's job (...) to offer an analysis of [such a] very common mode of thought, and if he can offer a satisfactory analysis of real historical examples, so much the better.¹

According to Gisbertus Voetius (1589-1676), all individuality would be lost in a Cartesian universe. If we were to accept Descartes's view that there are no substantial forms of things, says Voetius, 'all created substances would merely be accidental beings, collections, aggregates, and not essences or unique natures by themselves'.² What would then be the difference between 'a wolf, a sheep, a whale, an elephant, a snake, a stone, a tree, a turnip, an aconite, wheat, the Sun, the Moon, the Earth?'³ Voetius, the senior theologian at the University of Utrecht, warns his students that metaphysical demarcation-lines between specific sorts of things are at risk. In a mechanical universe, all species will lose their 'substantiality'. To save it, Voetius defends the notion of 'form'. Form defines substance, since it cannot be because of their matter that substances are distinguished. Matter, indeed, is common to everything. Accordingly, things must differ on account of their *substantial form*, the 'first root and first conception (...) that constitutes a thing in its proper being and distinguishes it essentially from others'.⁴

Now, however, the Cartesians come along and argue that we may do without the concept of substantial form. At the University of Utrecht,

¹ J. D. North, *The Universal Frame. Historical Essays in Astronomy, Natural Philosophy and Scientific Method*, London 1989, 306.

² Gisbertus Voetius, 'On the Natures and Substantial Forms of Things', in *Selectarum Disputationes Theologiarum*, Pars I, Johannes à Waesberge, Utrecht 1648, 873. A French translation may be found in René Descartes et Martin Schoock, *La querelle d'Utrecht*, Textes établis etc. par T. Verbeek, Paris 1988, 107. The text served as the material for an academic disputation which was held at the University of Utrecht on 23 and 24 December 1641 with Voetius acting as *praeses*. See J. A. van Ruler, *The Crisis of Causality. Voetius and Descartes on God, Nature and Change*, Leiden 1995, 9.

³ Voetius, *Select. Dispp.* I, 872 / *Querelle*, 106.

⁴ Voetius, *Select. Dispp.* I, 875 / *Querelle*, 108.

Henricus Regius (1598-1679), the professor of medicine and botany, tried to 'plant the flag' of this *new philosophy*.⁵ With regard to substantiality, Regius readily admits that new philosophers like himself 'reject all substantial forms, of which it is said that they are substances, or constitute a part of the substance of natural objects'. He explains that substantial aspects of things do not derive from forms, but 'solely from matter, or corporeal substance'. To be sure, there are *forms* as well:

The form (...) I hold in one sense to be something peculiar to human beings, which is the human mind, or the incorporeal substance with which we perform our actions of thought. In another, general, sense, I say that 'form' is common to all natural things, in which sense it is commonly called the 'material form', which consists of a combination of motion or rest, as well as of the position, shape and size of the parts of matter which are united in natural objects⁶

The new philosophy thus explains the differences of natural things as differences of *material* formation. Some things are larger or smaller than others; things differ on account of their shape and they may be made of an infinite variety of parts that differ in size, motion and internal disposition. Natural variety, in other words, is a question of material configuration.

Voetius was not at all impressed by this alternative. Indeed, the differences of movement, size, shape and position are exactly the type of differences which he labels 'accidental'. For this reason alone they are wholly inadequate as characterisations of substantial being: 'accidents cannot compose or constitute a substance'. But what is the distinction between substance and accident meant to explain? This may come out more clearly in Voetius's argument from corruption. If a horse or a dog ceases to be, Voetius explains, this cannot be on account of its matter. For the matter is incorruptible and it is not destroyed. Therefore, 'it must be the form, by which it is brought about that the *compositum*, that is to say this horse, this

⁵ Henricus Regius, *Testimonium Academiae Ultraiectinae et Narratio Historica quæ defensæ, quæ exterminatæ novæ Philosophiæ*, Utrecht (Wilhelmus Strickius) 1643, 15 / *Querelle*, 88. See also T. Verbeek, *Descartes and the Dutch: Early Reactions to Cartesian Philosophy 1637-1650*, Carbondale 1992, 13ff.

⁶ Regius, *Responsio, sive Notæ in Appendicem ad Corollaria Theologico-Philosophica D. Gisberti Voetii*, Utrecht 1642, 20. Regius's *Responsio* generally follows what Descartes had suggested to Regius in reply to Voetius's essay 'On the Natures and Substantial Forms of Things'. See the Letter to Regius of January 1642, *Œuvres de Descartes*, eds. C. Adam and P. Tannery, Paris 1964-1971 (=Paris, 1897-1913) [hereafter; AT], vol. III, 458-510 / *The Philosophical Writings of Descartes*, transl. J. Cottingham, R. Stoothoff, D. Murdoch and A. Kenny, Cambridge 1985-1991 [hereafter: CSM], vol III, 205-209. See also René Descartes, *Lettres à Regius et Remarques sur l'explication de l'esprit humain*, Texte latin, transl. G. Rodis-Lewis, Paris 1959, 70-101. In this particular passage, Regius adds some arguments of his own against the notion of substantial forms. Descartes himself generally preferred the more cautious strategy of ignoring the question altogether.

dog etc., dissolves and becomes a *non-being*'.⁷ If accidental factors were to be the cause of the corruption of a composite object, the end of the substance were to be brought about on account of the (material) destruction of a thing (*per interitum*). In that case, however, a dead man would differ only accidentally and not substantially from a living one, that is, no more than an ill man differs from a healthy man, or someone sitting down from someone standing up. This is what happens when the forms are done away with and 'all created substances' are regarded as 'beings *by accident*', collections, aggregates' and not as 'single essences or natures *by themselves*'.⁸

Accordingly, the new philosophy had some important questions to answer. Its rejection of the forms is at once a rejection of individuality—and, in the end, a threat to *personal* individuality as well. Regius makes an effort to redefine the individual. Instead of the substantial form, he introduces a new concept, the notion of 'essential form', which he defines as the specific combination of accidents (that is of measure, shape and motion and the like) particular to a substance. In reply to Voetius's argument from corruption, he says: 'there is no 'corruption of the substantial form', but only of the essential form, which consists of the aforementioned suitable combination of accidents'. In other words, a recombination of accidents may lead to a corruption of the specific essence. This happens when an essential combination is altered. If someone is shot, he may be killed because the bodily structure which is essential to him is altered. The difference between a dead man and a living one may still be said to be greater than the difference between the same man standing up and sitting down, since in the latter case, the essential bodily arrangement remains the same. In this way, accidents *can* 'constitute or change the essence of things' and dead and living objects may indeed be said to 'differ essentially even if no substantial difference stands between them'.⁹

Voetius's conclusion, in other words, that in the Cartesian universe all substances would only be aggregates, collections or accidental heaps of matter, may be somewhat overstated. The new distinction Regius draws between essential and accidental properties of things can account for aspects of individuality as well—even in a purely mechanical world. This, however,

⁷ Voetius *Select. Dispp.* I, 875 / *Querelle*, 108.

⁸ Voetius, *Select. Dispp.* I, 873 / *Querelle*, 107. Voetius uses quotation marks and may be paraphrasing David Goriæus, *Excercitationes Philosophicæ quibus Vniversa fere discutitur Philosophia Theoretica. Et Plurima ac præcipua Peripateticorum dogmata evertuntur*. In Bibliopolio Commeliniano (Sumptibus viduæ Ioannis Comelini) 1620, 265–266: 'Neque in hisce rebus [the context concerns the human mind as the informing form of the human body] ita compositus datur ullum ens per se unum, quod indigeat aliquâ substantiâ, à quâ in unitate contineatur; sed entia sunt per aggregationem. Ita in rebus animatis datur corpus and anima, ex quibus componuntur, in rebus mixtis elementa'.

⁹ Regius, *Responsio*, 22.

does not diminish the significance of Voetius's objections. If the structure of the universe is determined according to the mechanical arrangement and re-arrangement of its parts, all differences between things natural must be due to material configuration only. Combinations of matter may not be accidental to the individual, but they are in a way 'accidental' to the material world at large. History would prove that Voetius's analysis was right, even though his opposition to the new philosophy was pointless. Within an extremely short period of time, the idea that natural philosophy could do without the distinction between substance and accident became almost universally accepted.

1. *Substances mechanical and philosophical*

In his *Essay concerning Human Understanding* of 1689, John Locke discusses a variety of questions with respect to substantiality. In Locke's view, the internal construction or 'Constitution' of a thing provides the actual basis for its uniqueness. But whereas Descartes and his followers were inclined to offer speculative accounts of world's interior, Locke shows himself to be very sceptical with respect to the possibility of knowing the microscopic mechanisms of things:

There is not so contemptible a Plant or Animal, that does not confound the most enlarged Understanding (...). When we come to examine the Stones, we tread on; or the Iron, we daily handle, we presently find, we know not their Make; and can give no Reason, of the different Qualities we find in them. 'Tis evident the internal Constitution, whereon their Properties depend, is unknown to us.¹⁰

Not knowing the *Constitution* of natural substances, we have to satisfy ourselves with 'the different Qualities' we observe in them. This is what the 'nominal essence' (as against the 'real essence') amounts to: a collection of *ideas* resulting from our observation of the outward form, or the phenomenal qualities of things. The nominal essence may be refined by choosing a more specific collection of the 'ideas' that we observe in bodies of a certain type, but this will bring us no further in our attempt to know their real essence. Locke describes the nominal essence of gold as 'a Body yellow, of a certain weight, malleable, fusible, and fixed'. The nominal essence of man may include the qualities of 'voluntary Motion', sense and reason and 'a Body of a certain shape'. We know much less, however, of the *real* essence of gold

¹⁰ John Locke, *An Essay Concerning Human Understanding*, ed. P. H. Nidditch, Oxford 1983³, III, vi, § 9, 444. See also *Essay* IV, vi, § 11, 587: 'We cannot discover so much as that *size, figure, and texture* of their minute and active Parts, which is really in them'.

or of man, which forms the 'foundation of all those Qualities'. What inner constitution makes a gold bar look yellow or a man being able to move himself? If we knew that, says Locke,

our *Idea* of any individual *Man* would be as far different from what it now is, as is his, who knows all the Springs and Wheels, and other contrivances within, of the famous Clock at *Strasburg*, from that which a gazing Countryman has of it, who barely sees the motion of the Hand, and hears the Clock strike, and observes only some of the outward appearances.¹¹

Locke thus explains his twofold notion of essence by reflecting on the inner nature and outward appearance of a mechanical device. A clock's inner construction is what causes the outward phenomena of the regular movement of its hands. Examining this movement and other features of the outward appearance of clocks and watches may offer a working definition of the 'nature' of a clock. Yet this will never bring us closer to a knowledge of the mechanism that is essential for its operation.

According to Locke, the traditional analysis of substances *per genus et differentiam* was based on the outward appearances of things. What philosophers had formerly regarded as the essences and species of things are in fact nothing but *nominal essences*, abstract collections of outward appearances.¹² Such supposedly incorruptible and eternal essences are derived from the complex ideas we have of things, but not from the 'precise, distinct, real *Essences* in them'. They are, in other words, '*made by the Mind*, and not by Nature'. Small wonder, then, that the definitions which are based on such nominal essences cannot serve as reliable criteria for classification. Locke argues that if a monstrous child is born and people ask themselves whether or not it should be baptised, the definition of *animal rationale* does not offer much help.¹³ Indeed, nature itself is indifferent to the metaphysical classes which philosophers erroneously present as the roots of specificity. If there were to be immutable species in nature, then what must we think of the propagation of mules, in which case nature seems to follow neither the species of horse nor of ass, but appears 'to have jumbled them both together'?¹⁴

Nature, says Locke, produces many particular things. Because of certain likenesses between them, we make classifications, inventing species and sorts to which specific names can be given. But 'such a manner of sorting of

¹¹ Locke, *Essay* III, vi, § 9, 442.

¹² Cf. P. Phemister, 'Locke, Sergeant, and Scientific Method', *The Rise of Modern Philosophy. The Tension between the New and Traditional Philosophies from Macchiavelli to Leibniz*, ed., T. Sorell, Oxford 1993, 240–245.

¹³ Locke, *Essay* III, vi, § 26, 453–454.

¹⁴ Locke, *Essay* III, vi, § 23, 451. For the example of the mule and its relation to the concept of substantial form, see Van Ruler, *The Crisis of Causality*, 37–70.

Things, is the Workmanship of Men'.¹⁵ It could be applied to artificial things as well: 'For why should we not think a Watch, and a Pistol, as distinct Species one from another, as a Horse, and a Dog, they being expressed in our Minds by distinct *Ideas* (...)?'¹⁶ Our classifications of objects, natural and artificial alike, depend on the differences we observe. Nature itself may have produced—and indeed, probably *has* produced—internal patterns of things that correspond to the outward patterns we see, but our definitions pertain to outward appearances only.

Where Locke was primarily concerned with exposing the obscurities and paradoxes of traditional philosophical doctrine, others were of a more scientific mind. Right at the start of *A Free Enquiry into the Vulgarly Received Notion of Nature*, Robert Boyle (1627-1691) distinguishes between the various uses made of the concept of 'nature'. 'Nature' may refer to the mechanism of a thing (or, on a larger scale, to the natural world itself) or, in another sense, to a thing's essence, its 'quiddity', or 'whatness'. In fact these are only two of the many senses in which the term 'nature' is used. Boyle clearly distinguishes the meaning of 'essence' from that of 'structure'. Nevertheless, he identifies 'the complex of essential properties or qualities' with 'the structure or the texture' of a body, thereby indicating to what extent he too endorses the Cartesian view that essences may be reduced to internal constitution and 'fabric'.¹⁷

Boyle regards the custom of referring to the 'nature' of a thing as a convenient shorthand description. Yet it does not help the natural philosopher, since, 'when a man tells me that 'nature does [such and such] a thing', he does not really help me to understand or to explicate how it is done'. It is up to the new science to explain how

whatsoever is done in the world, at least wherein the rational soul intervenes not, is really affected by corporeal causes and agents, acting in a world so framed as ours is according to the laws of motion settled by the omniscient author of things.¹⁸

Boyle urges philosophers to look for causes in cases where formerly 'nature' had been the final word. In his book on *The Origin of Forms and Qualities, According to the Corpuscular Philosophy*, he restates Locke's view that we do not in fact distinguish gold from brass on account of their substantial forms, but only by the accidents and qualities we observe in them and which 'do themselves proceed from those primary and catholick affections of

¹⁵ Locke, *Essay* III, VI, § 37, 462.

¹⁶ Locke, *Essay* III, VI, § 41, 465.

¹⁷ R. Boyle, *A Free Enquiry into the Vulgarly Received Notion of Nature*, eds. E. B. Davis and M. Hunter, Cambridge 1996, 22–23.

¹⁸ Boyle, *Free Enquiry*, 34.

matter, bulk, shape, motion, or rest, and the texture thence resulting'.¹⁹ Our knowledge of the 'real' species of things is rudimentary: are water and ice for instance of the same sort—and what about wine, alcohol and vinegar? What to say of the egg and the chick; the caterpillar and the butterfly? Are a glowing piece of coal and one immersed in water specifically identical? Are clouds, rain, hail and snow of the same type? Are paper and glass made from the same species as their base materials?²⁰

These are all problematic examples, 'instances of a disputable nature', but Boyle is convinced that it has at least been proven that all forms are the result of specific material constructions. His argument is that natural forms may be produced 'mechanically'. Boyle describes his experiments with metals and sulphuric and nitric acids (*oil of vitriol* and *aqua fortis*), in which he made various sulfates and nitrates. He observes that these 'factitious vitriols' have exactly the same qualities as the vitriols found in nature and concludes that 'our knowing what ingredients we make use of [in factitious vitriol], and how we put them together, enables us to judge very well how vitriol is produced [in nature]'. Accordingly, Boyle conjectures that other minerals are likewise to be regarded as 'vitriols' of certain metals and that 'by distillation and reduction' an acid 'saline spirit' and a 'metalline substance' may in turn be recovered, like copper from blue vitriol. Boyle had quite some problems with producing 'a blue venereal vitriol out of copper' himself. Having observed that copper and sulphuric acid do not react, he tried successfully with nitric acid. Still, he had to make quite an effort to extract the 'desired body' of copper nitrate from the reaction. When he finally did, the result proved to be 'one of the loveliest vitriols that hath perhaps been seen,' so that Boyle decided to carry a portion of it with him 'for a rarity'.²¹

The mere possibility of such chemical manipulations was, according to Boyle, a clear indication of the fact that shapes and qualities of substances are the result of texture. The colour, shape, taste and chemical properties of the crystals in their laboratory from agree to those of the 'native' crystals. Besides, the qualities of the crystals differ according to the ingredients used. Boyle therefore concludes that they are the result of 'the juxta-position of metalline and saline corpuscles' and not of some substantial form.²² Still,

¹⁹ R. Boyle, *The Origin of Forms and Qualities, According to the Corpuscular Philosophy*, *The Works*, ed. T. Birch, Hildesheim 1966, vol. III, 28.

²⁰ Boyle, *The Origin of Forms and Qualities*, *Works* III, 50–51.

²¹ Boyle, *The Origin of Forms and Qualities*, *Works* III, 52–54.

²² R. Hooykaas discusses experiments similar to Boyle's by Angelo Sala (1576–1673). According to Sala however, the possibility of composing and decomposing vitriol indicates that, 'whether artificial or natural, [vitriol] is only an apposition of particles of copper, acid,

even in Boyle's experiments, the supposed material texture and mixture of chemical substances remains a matter of hypothesis. Although the corpuscular philosophy offered a more likely model for chemical reactions than the Aristotelian theory of forms and mixtures, Boyle's corpuscularian conviction at the same time kept him from accepting the idea of basic elements.²³ In the end, he does not come very much further in finding the real, material essences of things. Still, the only way to arrive at decisive answers concerning the nature of specific substances, was to continue in the way Boyle did, that is, by exploring the possibilities of chemical analysis.²⁴ As far as the problem of real essences is concerned, specific definition had to yield to scientific practice and chemistry replaced philosophy.

As for philosophy itself, the new mechanical conviction completely changed ontological hierarchies. Indeed, what *substances* inhabit and furnish the world if not Voetius's whales and elephants, stones and trees and turnips? The new philosophers gave priority to corpuscles instead of macroscopic objects and no longer distinguished between artifacts and natural things. Descartes had suggested that all of Voetius's arguments in favour of substantial forms might just as well be applied to the form of a clock, 'of which no one will say that it is substantial'.²⁵ As we have seen, Locke followed suit, comparing even man himself with the famous clock at Strasbourg. Not only did philosophers like Descartes, Regius, Locke and Boyle regard all visible objects as mechanically equal, they also saw natural objects as being connected in a universal chain. Locke's pessimism about the possibility of finding real essences was partly due to the fact that, according

and water, an accidental being, not an essential unity'. Cf. R. Hooykaas, 'The Experimental Origin of Chemical Atomic and Molecular Theory Before Boyle', *Chymia* 2 (1949), 78.

²³ This, according to Rupert Hall, 'prevented him from taking any step towards the modern conception of the chemical element'. A. Rupert Hall, *The Scientific Revolution 1500–1800; The Formation of the Modern Scientific Attitude*, Boston 1966, 324. Accordingly, others stood closer to the modern notions of the element and the molecule. A prefiguration of the concept of molecule may be found in the works of Sebastian Basson and Isaac Beeckman in particular. Cf. H.H. Kubbinga, 'Les premières théories "moléculaires": Isaac Beeckman (1620) et Sébastien Basson (1621). Le concept d' "individu substantiel" et d' "espèce substantielle"', *Revue d'Histoire des Sciences* 37 (1984), 215–233.

²⁴ Once philosophers accepted the idea that by chemical analysis 'mere aggregates' could be distinguished from 'true compounds', the concept of 'true compound' was itself at stake. Cf. R. Hooykaas, 'The discrimination between "natural" and "artificial" substances and the development of corpuscular theory', *Archives internationales d'histoire des sciences* 1 (1947), 644: 'Of course here the Trojan horse was drawn in; the Aristotelic conception of chemical combination was now wholly at the mercy of the state of chemical knowledge'.

²⁵ Descartes to Regius, January 1642, AT III, 505 / ed. G. Rodis-Lewis, 90 / CSM III, 208. Regius brings up the same argument. Cf. *Responsio*, 22: 'Omnes autem hujusmodi rationes, quæ ad formas substantiales probandas adduci solent, exactissimè formis horologiorum aliorumque *automatôn* applicari possunt, quas tamen nemo substantiales esse dixerit'

to him, all 'the great Parts and Wheels (...) of this stupendious Structure of the Universe' are causally interconnected:

Things, however absolute and entire they seem in themselves, are but Retainers to other parts of Nature (...). Their observable Qualities, Actions and Powers, are owing to something without them; and there is not so complete and perfect a part, that we know, of Nature, which does not owe the Being it has, and the Excellencies of it, to its Neighbours.²⁶

An object which, from an external point of view, we regard as a substantial unity, may owe its apparent form not only to its inner constitution, but also to the influences it receives from its mechanical environment. The new philosophy thus presupposes a causal interconnection of natural activity and, as a result of the materialistic conception of an object's real essence, this causal continuity in the physical sense reflects an ontological continuity of being.

2. *The universal substance*

If substances are what they are not because of what they look like, but because of their internal design and if their internal design is dependent on the design of the world at large, a complete account of any individual substance would involve a complete account of nature itself.²⁷ Accordingly, Robert Boyle argues that 'the particular nature of an individual body consists in the general nature applied to a distinct portion of the universe'. He defines 'general nature' itself as

the result of the universal matter or corporeal substance of the universe, considered as it is contrived into the present structure and constitution of the world, whereby all the bodies that compose it are enabled to act upon, and fitted to suffer from, one another, according to the settled laws of motion.

Here we find the climax of corpuscularism. The possibility that individual substantiality might be lost—a possibility that had so much disturbed Voetius, Boyle now presents as the only acceptable one. In fact he explicitly subscribes to a thesis Voetius had thought absurd: 'nature is the *aggregate* of the bodies that make up the world'.²⁸ In less than half a century, the concept

²⁶ Locke, *Essay IV*, vi, § 11, 587.

²⁷ Van Ruler, *The Crisis of Causality*, 199–240.

²⁸ Boyle, *Free Enquiry*, 36 (my italics). Cf. also *The Origin of Forms and Qualities*, *Works III*, 20: 'we must consider each body, not barely, as it is in itself, an entire and distinct portion of matter, but as it is a part of the universe, and consequently placed among a great number and variety of bodies, upon which it may act, and by which it may be acted on, in many ways (or upon many accounts) each of which men are wont to fancy as a distinct power or quality in the body by which those actions, or in which those passions, are produced'.

of individual substance had all but disappeared, leaving the notion of a single, unique and homogeneous substance to take its place.

If observable entities are not to be regarded as single substances in themselves, but as modifications of a universal substance, the question may be raised what this substance itself is like. At first sight, the material substance of the mechanical philosophy brings to mind an older, Aristotelian conception. Aristotle had looked for the *ousia* not only in composites of matter and form, but also in matter as such.²⁹ Yet what in Scholastic philosophy became known as the *materia prima* is not to be identified with matter in its mechanical form. Aristotle's notion of an ultimate material principle is primarily a logical conception. It offers a common analytical ground to all existing composites of form and matter. Contrary to the universal matter of the mechanical philosophy, it is not 'common' to things in a physical way. In the mechanical world things are quite literally *made of* matter—indeed, according to corpuscular philosophy, matter is *all* that everything is made of.

The question of what remains when nature is stripped of its specific forms—a perplexing question in the Aristotelian context—is, at least at first sight, easily answered from the point of view of the corpuscular philosophy. If nature be stripped of its specific forms, what remains is nothing but nature itself, since matter remains and matter alone is what constitutes natural objects. We have already quoted Henricus Regius, who in 1641 argued that substantial aspects of individual things derive 'solely from matter, or corporeal substance'.³⁰ By 1686, Boyle could confidently claim to speak on behalf of 'the generality of philosophers (...) that there is one catholick or universal matter common to all bodies, by which I mean a substance extended, divisible, and impenetrable'.³¹ This description of extended substance is obviously framed on the Cartesian model of mechanical nature. But what does it mean for matter and substance to be identical?

Arguing, like Boyle, that there is a universal matter to all bodies, the mechanical philosophers were inclined to see 'substance' as a kind of basic material, like iron or bronze, but then without specific qualities apart from being extended. Descartes even proposes to substitute the concept for extension itself.³² The result is that material things are thought of as if they are 'made of extension' in the same way as a statue is made of bronze. But how could one imagine such a thing? If we really do take away all qualities apart from extension, then what, exactly, remains? Something extended in

²⁹ Aristotle, *Metaphysics*, 1017b23–24.

³⁰ Regius, *Responsio*, 20.

³¹ Boyle, *The Origin of Forms and Qualities*, Works III, 15.

³² See below, note 39.

three dimensions, divisible and impenetrable, is the answer we are likely to get from a late seventeenth-century philosopher. Yet even amongst the champions of mechanicism, there were those who had serious problems with this notion. John Locke doubted whether the concept of a universal substance was a workable one. In the Lockean epistemology, all knowledge depends on the ideas we perceive. The senses receive a variety of qualities which are thought to inhere in a substance. Yet of this substance itself we do not have any idea.³³ The idea of universal matter, in other words, remained as impenetrable to the imagination as the chemical structure of substances remained impenetrable to sense. Our ideas do not give us any positive account of substance except as it appears disguised in the clothes of observable qualities. In 1710, George Berkeley (1685-1753) could therefore assert that

the vague and indeterminate description of Matter or corporeal substance, which the modern philosophers are run into by their own principles, resembles that antiquated and so much ridiculed notion of the *materia prima*, to be met with in Aristotle and his followers.³⁴

Of course, apart from Berkeley, no one believed that we could really do without the notion of a 'something'—whatever it is—that is the physical bearer of our impressions. All the same, philosophers were increasingly baffled by the notion of substance, especially since Berkeley and, in his footsteps, David Hume, took Locke's empiricism to the extreme and denied that we have a privileged access to the qualities of matter through the senses of feeling and sight.³⁵ Thus, in the empiricist philosophy of the eighteenth century, the concept of substance became ephemeral. Yet in order to see why the notion of an extended substratum was problematic, it is important to notice that the idea of substance was not merely called into question on epistemological, but rather on logical grounds.

³³ Locke, *Essay* II, XXIII, § 2, 295: 'So that if any one will examine himself concerning his *Notion of pure Substance in general*, he will find he has no other *Idea* of it at all, but only a Supposition of he knows not what support of such qualities, which are capable of producing simple ideas in us'.

³⁴ George Berkeley, *A Treatise Concerning the Principles of Human Knowledge* § 11, in *The Works of George Berkeley*, eds. A. A. Luce and T. E. Jessop, vol. II, London 1949, 46.

³⁵ George Berkeley, *Principles*, § 14–15, *Works* II, 46–47. Berkeley denies that a distinction between qualities that do and qualities that do not exist independently of our perception could be made intelligible. Our ideas of extension, figure and motion are no less dependent on observation as are our ideas of colour and sound. See also D. Hume, *Enquiry concerning Human Understanding*, Sect. XII–II, § 122, ed. L. A. Selby-Bigge and P. H. Nidditch, Oxford 1975, 154: 'The idea of extension is entirely acquired from the senses of sight and feeling; and if all the qualities, perceived by the senses, be in the mind, not in the object, the same conclusion must reach the idea of extension, which is wholly dependent on the sensible ideas or the ideas of secondary qualities'.

3. *The logic of substance*

Locke says that if someone were asked in what 'subject' a quality, for example a colour, 'inheres', he 'would have nothing to say,' but that it inheres in the solid extended parts of matter. Yet being asked again 'what it is, that that Solidity and Extension inhere in', the philosopher would be in no better a position than the 'Indian'

who, saying that the World was supported by a great Elephant, was asked, what the Elephant rested on; to which his answer was, a great Tortoise: But being again pressed to know what gave support to the broad-back'd Tortoise, replied, something, he knew not what.

Substance likewise, being the supposed—but unknown—support of the qualities, is but a name for something we are, according to Locke, 'perfectly ignorant of'.³⁶ The same argument is found in Berkeley's *Principles*, where the notion of a 'material substratum or 'support' of figure, and motion, and the other sensible qualities' occurs as a general idea which is 'the most abstract and incomprehensible of all'.³⁷ The argument shows that Locke and Berkeley are as much troubled by the notion of a 'support' as by the empirical unknowability of brute matter from simple ideas. There are, in other words, inherent problems with the logical scheme or with the metaphysical image of 'substances supporting accidents'. If matter is thought of as a substance of which extension is the accident, we do not get a clear notion of what functions as the metaphysical support for the quality of being extended.³⁸

This problem had already been acknowledged by Descartes. In the *Principia*, Descartes observes that there is 'quite some difficulty in abstracting the notion of substance from the notions of thought or extension'.³⁹ We are making a conceptual distinction only when we distinguish the material substance from its primary attribute of being extended. Descartes defines substance as 'a thing which exists in such a manner that it needs no other thing for its existence'.⁴⁰ Strictly speaking, this may be said only of God, but in so far as the corporeal and thinking substances themselves depend only on God and not on anything else, we

³⁶ Locke, *Essay* II 23, 296.

³⁷ George Berkeley, *Principles*, § 16–17, *Works* II, 47–48.

³⁸ Locke and Berkeley use the notions of 'qualities' and 'accidents' interchangeably. Cf. Locke, *Essay* II 23, 295: 'which Qualities are commonly called Accidents', and Berkeley, *Principles*, § 16, *Works* II, 47: 'though you know not what [Matter] is, yet you must be supposed to know what relation it bears to accidents, and what is meant by its supporting them'.

³⁹ Descartes, *Principia Philosophiae* I 63, AT VIII, 31 / CSM I, 215.

⁴⁰ Descartes, *Principia Philosophiae* I 51, AT VIII, 24 / CSM I, 210.

may also regard these as 'substances' in a looser sense. Such substances, says Descartes, are not known simply because they exist. It is only because we perceive a certain attribute that we may conclude that 'there must necessarily be some existing thing, viz. a substance, to which [this attribute] may be attributed'.⁴¹ Since 'extension' and 'thought' are presupposed whenever anything is attributed to either minds or bodies, extension and thought are the primary attributes of the two types of things, or 'substances' which we find in nature. However, since they define the nature of these substances, extension and thought may also be regarded as what constitutes the thinking and the extended substances themselves. The concept of substance is separated from thought and extension because this enables us to see specific thoughts and extensions as modes of the universal substance.⁴² Nevertheless, it would be non-sensical to refer to a concept of 'mere substance' apart from its attribute. To think that such an abstract notion refers to anything real, is to deceive oneself. Indeed, according to Descartes, a concept 'is not any more distinct because we include less in it; its distinctness simply depends on our carefully distinguishing what we do include in it from everything else'.⁴³ In other words, the distinction between extension and thought leads us to conclude that there is 'extended substance' and 'thinking substance'. This does not mean that there are substances apart from extension and thought.

Aware of the fact that the notion of substance has only a limited use, Descartes nevertheless continues to make use of it and does not criticize the category of substance as such. We do, however, find a critique of the category of substance in the work of one of his followers. According to the Flemish philosopher Arnold Geulincx (1624-1669), the concept of substance is primarily a logical one. A substance is that to which the subject of a proposition refers. This logical, or even linguistic, interpretation of the notion of substance is not in itself anything new. In the *Categories*, Aristotle defines substance as that which is 'neither *said* of a subject, nor in a subject'.⁴⁴ Again, with respect to the idea of a *substratum*, substance is defined as that 'which is no longer *said* of anything else'.⁴⁵ What is new in Geulincx, is the fact that the logical foundation for our idea of substance is used as an argument against it: logical and linguistic distinctions are not

⁴¹ Descartes, *Principia Philosophiae* I 52, AT VIII, 25 / CSM I, 210.

⁴² Otherwise, specific modes could themselves be regarded 'as subsisting things'—a view that cannot be accepted, since all extensions are incorporated in the universal matter and thoughts are always linked to a single mind. Cf. Descartes, *Principia Philosophiae* I 64, AT VIII, 31 / CSM I, 215–216.

⁴³ Descartes, *Principia Philosophiae* I 64, AT VIII, 31, translation from CSM I, 215.

⁴⁴ Aristotle, *Categories*, 2a11–13. Emphasis added.

⁴⁵ Aristotle, *Metaphysics*, 1017b23–24. Emphasis added.

necessarily applicable to things as they are in themselves. Notions such as 'entity, substance, accident, relation, subject, predicate, whole and part', says Geulincx, characterize our way of thinking about objects. They are *modes*, or ways of thought, and although they do not themselves mislead us—since we know perfectly well what we mean when we distinguish a thing from its activity or from our judgement of it—we should not uncritically attribute our manner of understanding to things as they are in themselves. Much less should categories be formally consented to or even form the basis for all philosophy, as they do in the Schools.⁴⁶ What we call a substance, or a thing in or by itself (*Ens in se, aut etiam Ens per se*), is that which can, without further linguistic additions, adopt the form of a subject (*ratio subjectis, seu Entis*). Thus, concepts like 'man', 'stone' and 'wood' may function in the subjective or substantive form. The case is not the same for a concept such as 'pleasant', which 'does not have the form of a subject, unless you would expressly or implicitly add to it the mark of a subject, viz. 'thing', or 'what is'.⁴⁷ In this way, an adjective is given a substantive form and can be used as a subject, for example in the proposition 'what is pleasant pleases', or 'a pleasant thing pleases'.

Now some of our words are primitive nouns, whereas others are adjectives (although they may be transformed for substantive use). The adjectives function as the accidents of Aristotelian philosophy. The nouns stand for substances. Still, the reason for making such distinctions is unclear. Aristotelians argue that the distinction between substance and accident is grounded in the fact that substances are things in themselves, whereas accidents are 'in' some other thing. According to Geulincx this is not a genuine explanation. Things are only said to be 'in' something else as a consequence of our way of seeing things:

It is not evident why the fact that 'whiteness is in snow' would be the reason why snow is white rather than the other way round; in fact the only reason why 'whiteness' is said to be 'in snow', is that snow is white.⁴⁸

In other words, the supposed *in-esse* of accidents follows our way of expression. Aristotle's definition of substance as that which is 'neither said of a subject, nor in a subject' offers no answer to the question which comes first: *in-esse* or expression. His Scholastic followers argued that 'denomination follows in-existence'. In defence of their view they say that an accident is 'completely distinct' (*condistinctum*) from its subject, which

⁴⁶ Arnold Geulincx, *Metaphysica ad mentem Peripateticam*, in: *Sämtliche Schriften in fünf Bänden*, ed. H. J. de Vleeschauwer, Stuttgart 1968 [= ed. J. P. N. Land 1891, hereafter: *Opera*], vol. II, 206–209.

⁴⁷ Geulincx, *Opera* II, 215.

⁴⁸ Geulincx, *Opera* II, 217.

means that substances and accidents form mutually exclusive classes. Again, accidents are said to 'penetrate' subjects by filling their space. Furthermore, accidents are characterized by their 'mode of posterior attainment' (*modum posterioris advenientis*) and, finally, they do not form a single entity or nature with their subject.

Discussing these arguments, Geulincx comes to the conclusion that they are null and void. First, accidents and substances do not in fact form exclusive classes, since no accident can be thought of without a subject. The idea of 'penetration', moreover, is nonsensical, since no material thing can 'penetrate' another in the absolute sense of filling its space. Nor do spiritual beings penetrate others in this way, since what is spiritual is by definition without spatial dimensions. Further, the argument that accidents do not form a single unity with their subject begs the question, since the notion of 'accident' is itself defined as that which is not essential to the 'single nature' itself. It is only by its 'mode of posterior attainment' that an accident is really distinguished from its subject. Yet, according to Geulincx, it is completely unclear what philosophers mean by this. Subjects are somehow supposed to 'precede' accidents. Everyone agrees that they do not do so in a temporal way. Therefore, subjects must precede accidents 'by nature'. Yet no-one has thus far been able to explain wherein this natural precedence lies. In order to make sense of the idea, one must always revert to some mode of thought—which brings us back to where we started.

According to Geulincx, the question of *in-esse* does not explain the difference between substances and accidents. Traditional metaphysics only follows our linguistic distinction between substantives and adjectives—and not even this is completely true.⁴⁹ Instead of being distinguished by their *in-esse*, the difference between first and second substantives (that is, between primitive and derivative nouns) may be a function of the stability of our impressions:

The real cause (...) may be, that people see some things as more firm, stable and lasting, others as more fluid, fleeting and frail. Thus (...) light and darkness, colours and sounds and all similar things are regarded as more fluid than body or extension.⁵⁰

In attributing the concept of substance to certain things and that of accident to others, our intellect, in other words, follows our senses, which continually

⁴⁹ As Geulincx argues in a note, we say that there is motion 'in' a body that moves, but we may also say that the body itself is 'in motion', or 'in rest'. Why should we not equally affirm that 'snow is in whiteness' or that 'Hercules is in strength'? This would even be a more philosophical way of expressing ourselves. Indeed, we should say that substances are 'in' accidents, since the idea of a substance, or of a thing modified, is always 'included' in the notion of an accident or modification. Geulincx, *Opera* II, 304—305.

⁵⁰ Geulincx, *Opera* II, 305.

testify that fluid things are supported by firm ones rather than that firm things rest on fleeting things.⁵¹ Yet whether an accident or a quality is thought to be 'in something else' is, according to Geulincx, wholly dependent on our intellectual apprehension of it.⁵² The question might be asked how things in themselves are grouped together if the notion of substance and even the notions of 'thing' and 'entity' only result from our subjective way of seeing them. Are things as they are in themselves not divided into particular entities? Could we refer to them in other ways than as *entia* or *res*? Geulincx is remarkably straightforward in his judgement of things in themselves. Things in themselves are what they are: they are either minds or bodies, with an existence which is independent of our way of grasping them as a diversity of particular 'things'. Despite his conviction that we cannot grasp things 'as they are in themselves' without assuming a form that corresponds to the subject-predicate distinction, Geulincx does not seem to have any problems with knowing the *nature* of things. All things are what 'true'—that is, Cartesian—metaphysics teaches them to be: either minds or bodies. The problem Geulincx has with the concept of substance is one of individuation. Philosophy makes use of the concept of substance in order to distinguish individual substances from their so-called inherent accidents. This is illegitimate: our conception of individuality is only the result of our habit of reasoning in a subject-predicate form.

From Geulincx's point of view, it is clear what goes wrong if we look for a universal substance that has the property of being extended. The search for a universal 'something' of which the property of being extended is an 'accident' is bound to result in philosophical bewilderment, but this perplexity is only the result of the mistaken view that the world is organised along the lines of grammar. The universe, according to Cartesian standards, is simply what it is—viz., material—regardless of the fact that, on account of our linguistic habits, we *conceive* it as an individual 'whole' with 'material properties'. Geulincx's criticism of Aristotelian categories reflects what Descartes himself says where he argues that we should not abstract the notion of substance from the property of being extended. But if it is wrong to search for substances in nature, what led philosophers to suppose that there are such individual 'somethings' in the first place? To answer this question,

⁵¹ Geulincx, *Opera* II, 305.

⁵² Geulincx, *Opera* II, 220: 'an enim res in alio sit nec ne, quae per intellectum apprehensa est (in quo tota substantiam inter et accidens diversitas consistit), non pendet a re ipsa, quae per intellectum sumpta est, sed a modo sumendi seu apprehendendi nostro. Cum enim res aliqua sic sumpta est, ut de ea affirmare possis sine ullo addito vel subaudito, substantia sumpta intelligitur; cum vero nota aliqua addenda est, vel subaudienda, accidens sumptum esse intelligitur'. See also 218: 'adeoque totam rationem substantiae et accidentis penes hoc desumendam esse, quod altera quidem sit substantivum, alterum sit adjectivum primo'.

let us reconsider the nature of the revolution which the Cartesian philosophy brought about.

4. *Cartesian dualism*

Rejecting the notion of substantial forms, Henricus Regius put forward the idea that natural objects differ only in respect of their material accidents. Endorsing a similarly Cartesian point of view, Robert Boyle later asserted that nature is to be seen as an aggregate of bodies. The concept of individuality thus disappeared along with the concept of substantial forms. Individuality is not, however, completely rejected in Cartesian philosophy. While Descartes regarded substantial diversity in the natural world as the mere effect of matter in motion, the human mind forms an exception. As for the soul, individual substantiality is preserved. Or, as Regius puts it, besides the general material form of the arrangement of matter, there is also a form 'peculiar to human beings, which is the human mind, or the incorporeal substance with which we perform our actions of thought'.⁵³ The human mind is the only remaining hylemorphic composite in the Cartesian universe.⁵⁴ Descartes even calls the mind 'the only substantial form' and 'the true substantial form of man'.⁵⁵

It would be misleading to argue that Descartes simply rejected all substantial forms except for one on account of the fact that he could not do without a concept of personal identity or that he wanted to save the soul for religious reasons. Such a reconstruction is problematic for the reason alone that personal individuality is not a prominent theme in his works. Nor do we find a critique of the Aristotelian notion of individual existence, or of the notions of 'species' and 'essence'. Descartes's criticism of substantial forms is primarily implicit. It is to be found in the alternative he offers to the theory of the School philosophers that natural change is due to real qualities and substantial forms.⁵⁶ Descartes is most concerned with the notion of substance in its *causal* capacity. What he considers superfluous in the Aristotelian scheme, is the role that substances play as centres of physical activity. In the

⁵³ Regius, *Responsio*, 20.

⁵⁴ Cf. G. Lewis, *L'Individualité selon Descartes*, Paris 1950, 76: 'Cette composition hylémorphique prend une valeur toute particulière du faite même de son caractère privilégié'.

⁵⁵ Descartes to Regius, January 1641, AT III, 503: 'agnoscitur [Animam humanam] sola esse forma substantialis, alias autem ex partium configuratione and motu constare' and *idem*, AT III, 505: '[Anima] est vera forma substantialis hominis'. Cf. CSM III, 207 and 208 and Descartes, *Lettres à Regius*, 86 and 92.

⁵⁶ For an assessment of the link between Descartes's natural philosophy and his dualist metaphysics, see H. van Ruler, 'Het dualisme van Descartes: een herwaardering', *Tijdschrift voor Filosofie* 60 (1998), 269-291.

mechanical explanation of natural and physiological processes there is no need to postulate the existence of substantial forms or active qualities, since matter in motion itself may do the work.⁵⁷ Or, as Robert Boyle puts it, 'whatsoever is done in the world, at least wherein the rational soul intervenes not, is really affected by corporeal causes and agents, acting in a world so framed as ours is according to the laws of motion'.⁵⁸ What Boyle means by saying that 'whatsoever is done (...) is really affected by corporeal causes,' is that in fact *nothing* is 'done' by any 'agent' independently of the laws of motion. The clockwork of mechanicism admits of no centres of individual being with a causality of their own. Accordingly, no individual substances influence nature's course.

No agent, that is, except for one. The human mind is the only remaining *agent* in the universe. As Boyle indicates, corporeal causes are only effective in processes 'wherein the rational soul intervenes not'. The soul does not simply survive as the anomalous by-product of a mechanical universe tuned to Christian standards. Rather, according to the mechanist philosophers, the human soul should have remained the unique example of individual activity in the first place. Discussing the movement of the heart, Henricus Regius argues that there is no need to suppose that this operation stems 'from the soul, or informing form, through the mediation of qualities [operating] as principles and other instruments which are necessary for those movements'.⁵⁹ If the movement of the heart were to be a consequence of the operation of the soul, it would have to be conscious of this fact and 'would make use of the power of reason'. Descartes likewise claims that traditional physics makes improper use of the image of the soul as a metaphor for natural change. In a letter to Mersenne of 26 April 1643 he says: 'I do not suppose that there are in Nature any *real qualities*, which are attached to substances, like so many little souls to their bodies'.⁶⁰ 'Real qualities' and 'substantial forms' are entities that, in traditional physics, correspond to our idea of the active human soul, working on the body.⁶¹ Geulincx expresses the same idea, where he interprets the Scholastic notion of a quality as 'what is given to

⁵⁷ Descartes, *Météores*, AT VI, 239: 'Puis, sçachés aussy que, pour ne point rompre la paix avec les Philosophes, ie ne veux rien du tout nier de ce qu'ils imaginent dans les cors de plus que ie n'ay dit, comme leurs *formes substantielles*, leurs *qualités reelles*, and choses samblables, mais qu'il me semble que mes raisons deuront estre d'autant plus approuuées, que ie les feray dependre de moins de choses'.

⁵⁸ Boyle, *Free Enquiry*, 34.

⁵⁹ Regius, *Responsio*, 27.

⁶⁰ Descartes to Mersenne, AT III, 648. The translation is from CSM III, 216.

⁶¹ As Descartes wrote to Princess Elisabeth, the concept of active principles was a direct result of reading mental activity into nature: 'I think we have hitherto confused the notion of the soul's power to act on the body with the power one body has to act on another'. Cf. Descartes to Elisabeth, 20 May 1643, AT III, 667 / CSM III, 219.

substances in order to act'. The most important examples of such qualities are what Aristotelians call the 'potencies' and 'faculties' of substances, in other words, says Geulincx, the qualities to know, to desire and to move, which should in fact be attributed to the human mind alone.⁶²

Regius, Descartes and Geulincx interpret the idea of active individual substances as an unwarranted antropomorphic element in Scholastic physics. In physiology, there is no reason to appeal to the activity of the soul in order to explain the workings of the body. In physics, forms and qualities only introduce mentalistic properties which the mechanical philosophers regard as an unnecessary multiplication of entities, since the mechanical model makes them redundant. It is along with the disappearance of the 'soul' from physics that individual substances disappear from nature.

5. Substance and the individual

Apart from Arnold Geulincx, no seventeenth-century philosopher developed the theme of the antropomorphic aspects of Aristotelian physics in any detail. Neither do we find the idea that the notion of individual substances is itself the result of an antropomorphic projection. Looking back, however, this seems an all too obvious thought. In fact, personal identity not only functioned as the example *par excellence* of substantiality, but actually as its archetype. Defining 'substance' in the *Categories*, Aristotle uses the example of 'the individual man or the individual horse'.⁶³ In Descartes's days, the notion was more exclusively defended with reference to human individuality. Gisbertus Voetius argued in favour of a distinction between substantial and accidental change on account of the fact that without this distinction, we would not be able to make a difference between material destruction (which is seen as a form of accidental change) and substantial change. The crucial example is that of death, in which the 'substantiality' of the change is supposedly evident. Death involves the destruction of the unity of man and of personal identity in a way that sitting down, or losing an arm does not. It brings about the end of an individual agent and therefore the end of an individual centre of activity. The living individual is contrasted with the accidental properties he or she may have. When accidental properties change, for example when a person standing up suddenly sits down, no harm is done to the substantial source of change. Inactivity and the loss of individuality only occur at the moment of death, when the form itself is changed.

⁶² Geulincx, *Opera* II, 223–224.

⁶³ Aristotle, *Categories*, 2a13–14.

Likewise, Scholastic philosophy saw the *production* of substances as a generalization of 'birth'. In his widely read *Metaphysical Disputations*, Francisco Suárez (1548-1617) argues that all generation is 'really and essentially distinct from the whole preceding alteration'.⁶⁴ This is more or less equivalent to Voetius's argument that 'accidents cannot compose or constitute a substance'. Natural generation occurs in a variety of forms: elements bring forth their likes, and minerals, plants and animals are in a constant process of generation and corruption. The principal cause of the process of generation is the substantial form of the *generans*. This form, however, operates with the help of accidents that act as its instruments in producing the new substance. Thus, fire generates fire through the property of heat and man begets man through seed. However, when Suárez argues that the 'generation is really distinct from alteration', he means that, although they take part in the process, instruments like heat and semen do not contribute anything to the 'eduction' (*eductio*) of the new substantial form. The reason is, that the generation of the new substance is only incidentally the 'end' or *terminus* of the bodily process.⁶⁵ The argumentation here is drawn exclusively from the example of the human soul. The creation of the soul and its union with the body follow upon a physiological process, viz. the act of procreation and the development of the embryo. However, no one will deny that the creation of the soul and its union with the body is a distinct action from the bodily 'alterations'. A fortiori, says Suárez, 'the same will be true of other instances of generation'.⁶⁶ Thus, in late-Scholastic philosophy, substantial forms are natural counterparts to the human soul. Like a little soul, the form provides the substance with its individual *esse* and acts on a causal level that uses matter only as its instrument.⁶⁷

⁶⁴ Francisco Suárez, *Disputationes Metaphysicæ* 18, 2, 18, *Opera Omnia*, ed. Ch. Berton, vol. XXV, Paris 1877, 604. Francisco Suarez, S.J., *On Efficient Causality*, transl. A. J. Freddoso, New Haven 1994, 65.

⁶⁵ Suárez, *Disputationes Metaphysicæ* 18, 2, 17, *Opera Omnia* XXV, 603–604 / *On Efficient Causality*, 63–65. If not, 'heat would be a power for producing a substance in the same way that it is a power for producing heat—which, as is obvious from the very fact that a substance exceeds [an accident], is utterly absurd'. Cf. Suárez, *Disputationes Metaphysicæ* 18, 2, 22, *Opera Omnia* XXV, 606 / *On Efficient Causality*, 70.

⁶⁶ Suárez, *Disputationes Metaphysicæ* 18, 2, 17, *Opera Omnia* XXV, 604 / *On Efficient Causality*, 65.

⁶⁷ Since human souls are created directly by God, the question may be put whether there is in fact a genuine role left for substantial forms to play in generation. However, supplies of extra influences by the Sun, or even directly by God, are needed only in cases in which the instrumental accidents are *separated* from their 'connatural and principal' causes, such as is the case in the generation of man. In most cases—and leaving aside the question of God's general concurrence—substantial forms suffice as secondary causes 'with a true and proper causality' of their own. Cf. Suárez, *Disputationes Metaphysicæ* 18, 2, 23 and 28, *Opera Omnia* XXV, 607 and 608–609 / *On Efficient Causality*, 71 and 75ff.

Scholastic theory did allow for accidents themselves to be produced by 'accidental faculties', that is, apart from the activity of the substance or the 'form'. Thus, Suárez argues that the 'disproportionateness and distance that lie between' principles and actions necessitate the 'mediation of some proportionate means such as an accidental faculty or power'. Substance and accident lie too far apart for the one to be 'the total and proximate principle' of the other.⁶⁸ Indeed, according to Suárez, all non-intellectual operations which are not directed at the production of new substances, solely require powers of an accidental nature:

if those powers were nothing other than the substantial forms themselves, then all operations in question would remain in the substantial form alone. From this it would follow that operations of this sort in a human being are spiritual operations, in the same way that the form itself is spiritual.⁶⁹

Here, Suárez's type of reasoning comes close to the arguments of mechanical philosophers against the use of substantial forms in physiology. Regius argued that if a substantial form would direct our bodily mechanisms, we should have to be aware of this. But since we are not conscious of, for example, the operations of our heart, there is no reason to refer to the soul in order to explain its pulse.⁷⁰ Of course, in order to escape this conclusion, Suárez argues that there are accidental powers acting on behalf of the form. Likewise, Voetius replied to Regius that 'forms operate through natural faculties without reasoning'.⁷¹ But this is a dangerous line of argument. By emphasising the activity of accidents, the Scholastic theory itself gave rise to the question what need there is for substantial forms in explaining non-spiritual activity—which is exactly the question that Descartes was to put forward.

The natural precedence of substances over accidents which Geulincx found so incomprehensible is thus a precedence of identity over action. Like little souls, substantial forms bring identity into the world of non-animated individuals. The substance is the 'inner self' of things, having accidents which function as its observable characteristics and as the instruments of its action. The philosophers of Coimbra, arguing that 'no created substance may induce a substantial form without the instrumental help of accidents',

⁶⁸ Suárez, *Disputationes Metaphysicæ* 18, 3, 19, *Opera Omnia* XXV, 621 / *On Efficient Causality*, 105.

⁶⁹ Suárez, *Disputationes Metaphysicæ* 18, 3, 19–20, *Opera Omnia* XXV, 622 / *On Efficient Causality*, 105–108.

⁷⁰ Regius, *Responsio*, 27.

⁷¹ Voetius, *Select. Dispp.* I, 877 / *Querelle*, 110. The substantial form was thus set apart from natural action in order to avoid the conclusion that its operations would be 'spiritual without exception and in all [subjects]'. Cf. Suárez, *Disputationes Metaphysicæ* 18, 3, 20, *Opera Omnia* XXV, 622 / *On Efficient Causality*, 106.

nevertheless hold the substantial form to be the 'primary principle of action'. It is, in other words, only the inner self which is ultimately responsible for activity. What Voetius called the 'first root and first conception of every entity', is the same centre of individual being that the Conimbricenses call the 'first root and as it were the source from which an action of a natural thing comes forth'.⁷² Once again, the knowledge of such sources is linked to the knowledge of our soul.⁷³

Being put to use in descriptions of the natural world at large, the difference between substantial and accidental being was framed on the experience of ourselves as active individuals. Substantial change, however, does not merely affect the individual entity, but also the species it belongs to. In chemical examples the aspect of personal individuality does not have an obvious counterpart, since we find aggregates of chemical elements instead of individual portions.⁷⁴ In such cases, substantial identity is defined with respect to the identifiable group to which the object belongs. Biological diversity therefore seems to offer a better metaphor where specific substantiality is concerned. Yet even here the maintenance or loss of individuality provides the image for substantial change. Just as the dead human being is changed into a corpse with new formal properties, so a certain chemical element might 'lose' its substantiality when overpowered by another. Indeed, the medieval controversy over the question whether elementary forms are lost in a mixture, is only relevant within the context of searching substantial unity amidst accidental change. Whether one reads Aristotle through the eyes of Avicenna, Averroës or Aquinas, the problem of mixed bodies is a question of what happens to individual forms. The observable changes are evident, but the question is what goes on behind the scenes of the observable. Once it is postulated that there must be individual bearers of specific qualities, the identity of the new substance becomes a

⁷² *Commentarii Collegii Conimbricensis in octo libros Physicorum Aristotelis*, Lyons 1594, reprint Hildesheim 1984, II, 7, 18, vol. I, 295. See also above, note 4.

⁷³ On account of their empiricist theory of knowledge, the philosophers of Coimbra argue that, at least in acquiring knowledge (*inventio*), the knowledge of substances is preceded by knowledge of accidents. As an objection to this view, it is said that 'the Soul does not grasp (*intelligit*) anything prior to itself'. However, it is said, although the 'essential presence' of the soul always comes first, its 'objective presence' is determined only by reflection upon our awareness of sensible things. Accordingly, knowledge of accidents generally precedes the knowledge of substance. Conimbricenses, *In octo libros Physicorum*, I, 1, 5, vol. I, p. 78–81.

⁷⁴ Cf. R. Hooykaas, '“Individual” and “Species” in Chemistry', *Centaurus* 5 (1958), 315: 'In chemistry the notions of "individual" and "species" are often confounded (...). We apply the term "individual" to the substance in general (the species) as well as to geometrically limited proportions of it (crystals, drops)'. Hooykaas goes on to investigate crystals and molecules as candidates for chemical individuality, but concludes that the notions of individual and species in chemistry do not correspond to those in natural history ad that all 'analogies between biological and inorganic phenomena give rise to objections'. Cf. *idem*, 319.

mystery. Have the old forms disappeared when mixed? It was at least accepted that a new one had replaced them. Whether the *forma mixti* was seen as the result of a *remissio* of qualities, a *remissio* of forms, or a disappearance of 'actual' forms, the advent of a new substantial fundament proper to the new 'mediate' collection of qualities was unquestioned. It is not without reason that E. J. Dijksterhuis reverts to the example of the human being in criticizing the non-Aristotelian idea of a *remissio* of form. According to Dijksterhuis, 'being human' does not admit of 'more-and-less'.⁷⁵ However, the example of being human does not simply offer an illustration of the holistic character of form. The form is itself conceived as an inner identity analogous to the inner identity of man.

Scholastic theory did not regard qualitative changes as anything substantial. Such changes in a mixture only pre-dispose the matter undergoing the change to make room for the generation of a new form, the *forma mixti*. A new identity, in other words, is given to a pre-disposed body—which is exactly what happens when a soul is given to the new-born child. The chemistry of compounds was interpreted in terms of generation and since generation calls for a *generans* as its efficient cause, many were led to the conclusion that the *forma mixti* needed special assistance from Intelligences or heavenly virtues, or, as in the case of the human soul, from God himself as *generans mixti*.⁷⁶ Whether in a compound or in the form of *minima naturalia*, observable qualities and activities were thought to follow upon the presence of a 'substance'. The Scholastic idea of elementary and substantial change is best interpreted in terms of victory and defeat, of

⁷⁵ E.J. Dijksterhuis, *De mechanisering van het wereldbeeld. De geschiedenis van het natuurwetenschappelijk denken*, Amsterdam 1989⁶, 222: '*formæ sunt sicut numeri*: zoals een getal wel drie kan zijn, maar niet in meerdere of mindere mate drie, terwijl het, als het geen drie is, twee of vier of iets anders is, kan iets mens zijn of niet-mens, maar niet in hoge mate of een beetje mens'.

⁷⁶ A. Maier, *An der Grenze von Scholastik und Naturwissenschaft. Studien zur Naturphilosophie des 14. Jahrhunderts*, Essen 1943, 18: 'Es handelt sich hier ja um die Entstehung einer substantialen Form, und das Hauptproblem liegt in der Frage: was ist die Ursache dieser Entstehung, oder, anders formuliert: wer oder was ist das "*generans*"? Denn unter generatio und corruptio im eigentlichen, engeren Sinn des Worts wird immer ein Entstehen und Vergehen von substantialen Formen verstanden'. The idea that God directly acts as *agens principale* in generating the form of a mixture, is Nicolas Oresme's. Cf. Maier, *An der Grenze von Scholastik und Naturwissenschaft*, 128–133 and Dijksterhuis, *De mechanisering*, 224–225. Hooykaas, however, traces the idea that natural substances are God-given in early seventeenth-century chemical theory as well: 'An extremely prejudiced peripatetic like Palmarius (1609) says that only God can give the substantial Form. Art however is only able to dissolve what it has composed itself; in decomposing natural substances it never produces the same substances out of which Nature composed them'. Cf. Hooykaas, 'Natural' and 'Artificial' Substances', 645.

survival and loss.⁷⁷ To alter essentially is to die and to cease to be a specific individual.

The metaphor of personal individuality defines the third notion of substance as well: the universal subject or *substratum*. Here, the object of philosophical inquiry is the *ultimate* individual, the final bearer of any accident whatsoever—the fundamental subject underlying all specific habits, properties, characteristics, traits, features, attributes and qualities of things to be found in the world. Cartesian philosophy held on to this notion, reserving it for the idea of universal matter. However, as far as Descartes is concerned, this notion of ‘substance’ does not—or at least should not—bear the mark of a metaphysical substance framed on the image of the active individual. Such a concept would not in itself bring anything to light regarding the nature of matter. For Descartes, it was the distinction between extension and thought that counted. Extension and thought are the basic features of the world we experience. The one belongs to the natural world, the other to mind alone. We have no idea of what the world is like apart from these attributes. They should be regarded as the two ‘substances’ the world is made of. But there is no sense in trying to search for a substance as the individual ‘bearer’ of the attributes of thought and extension.⁷⁸

This mysterious bearer of attributes was exactly what Locke and Berkeley were not able to find. Locke concluded there must be a ‘something, I know not what’—allowing Berkeley the pleasure of ridiculing such a concept. We may now see what went wrong. Although the concept of substance could reasonably well be fitted into the everyday world of Aristotelian philosophy, the new idea of a universal matter needed new standards of conceptualisation. Philosophy, however, had no new concepts to offer. The notion of individual substances was universally rejected, but the rules of logic still allowed the question to be put what the ‘thing’ was like that had the ‘property’ of being extended. Accordingly, new attempts were made to explain nature as the effect of active and ‘substantial’ individuals.

⁷⁷ Maier, *An der Grenze von Scholastik und Naturwissenschaft*, 17–18: ‘Die Einführung einer neuen Elementarform setzt immer die vollständige Zerstörung der vorher vorhandenen Form voraus, sei es eine forma mixti—bei der Auflösung eines zusammengesetzten Körpers in die Elemente, die grundsätzlich in allen Fällen als möglich angenommen wird—, sei es, bei der Umwandlung der Elemente ineinander, die eines Elements’. R. Hooykaas also interprets the Aristotelian theory in terms of a ‘victory’ of the properties of one element over those of another’. Cf. ‘The Experimental Origin of Chemical Atomic and Molecular Theory before Boyle’, *Chymia* 2 (1949), 67. As we have seen, to Scholastic eyes, the ‘victory’ was a victory of the form rather than its properties.

⁷⁸ A. Geulincx goes even further, arguing that, if from thinking and extended being we abstract a notion of ‘being’ in general, this way of speaking does not refer to any real distinction. Cf. Geulincx, *Opera* II, 304.

6. *Modernist metaphysics*

Gottfried Wilhelm Leibniz went furthest in restoring individuality. Anticipating Berkeley and Hume, Leibniz argues that there is no legitimate reason to exclude all qualities except that of three dimensional extension from our idea of the world as it is in itself. His alternative to the Cartesian view is to re-introduce a 'principle of identity' apart from the sizes, shapes and movements of things, in other words, 'a substantial form'—even though, as he readily admits, it will make no difference to our experience of natural phenomena.⁷⁹ Leibniz's notion of the individual functions primarily as a guarantee for the existence of substantial activity apart from the activity of God. If no individual forms are active, God would do everything—a conclusion which, according to Leibniz, should be avoided.⁸⁰ He defines a substance's activity as the sum total of everything that will happen to a subject during its existence.⁸¹ From his example of what may be predicated of Alexander the Great it is obvious that his notion of *haecceitas* is founded on the idea of personal identity. Indeed, Leibniz is fully aware of the fact that the notion of substance originates in our experience of the self: it is 'only because of [the substantiality of our immaterial minds] that we have an awareness of substantiality at all'.⁸² Since he offers no further examples, it is not at all clear what other individual centres of activity or substantial forms Leibniz will accept. The only positive thing he says about the 'indivisible forms or natures', is that they play a metaphysical role as the 'causes of [our] appearances'.⁸³ Thus, a notion of substance is re-introduced which, based on the example of the human individual, is explicitly meant to offer a metaphysical basis for action.

Contrary to Leibniz and in good Cartesian fashion, Spinoza rejected the idea of individual natures. 'Bodies,' says Spinoza, 'differ from each other in respect of motion and rest, speed and slowness and not in respect of substance'.⁸⁴ Even so, Spinoza's own notion of substance may in some respects be seen as a return to the pre-Cartesian standard of substantiality. In Spinoza, the individual reappears on a larger scale: the 'whole of Nature is

⁷⁹ G. W. Leibniz, *Discours de Métaphysique*, § 12, ed. H. Lestienne, Paris 1986, 41–42.

⁸⁰ Cf. R.S. Woolhouse, *Descartes, Spinoza, Leibniz. The concept of substance in seventeenth-century metaphysics*, London 1993, 143ff.

⁸¹ Leibniz, *Discours*, § 13, 42: 'la notion d'une substance individuelle enferme une fois pour toutes tout ce qui luy peut jamais arriver'.

⁸² Woolhouse, *Descartes, Spinoza, Leibniz*, 155. From the *Textes Inédits*, Woolhouse quotes the following remark Leibniz made against Spinoza: 'That we are not substance is contrary to experience, since indeed we have no knowledge of substance except from the intimate experience of ourselves when we perceive the I'.

⁸³ Leibniz, *Discours*, § 18, 58.

⁸⁴ Spinoza, *Ethics* II, prop. 13, lemma 1.

one Individual'.⁸⁵ As such, this totality of nature (*natura naturata*) is not itself the cause of its activity. It is on nature in its role as the legislative or metaphysical ground of natural development (*natura naturans*) that natural activity depends. What is new in Spinoza, is that 'nature', 'God', or 'substance' takes the form of reality itself. This offers a whole new perspective, since reality is not 'caused' by anything in the usual sense of the word—which, according to Spinoza, is what it really means for God to be 'free' or for a substance to be 'by itself and conceived through itself'.⁸⁶ Moreover, following Descartes, Spinoza is well aware of the fact that there is no sense in distinguishing a substance from its attributes.⁸⁷ Accordingly, there is no substance to be found behind the scenes of thought and extension. Substance is identified with the 'attributes' or fundamental aspects of reality. As a result of their dynamic character, the attributes necessitate parallel chains of interconnected states or 'modes' of physical reality. However, even though the *natura naturans* is presented as a collection of properties or attributes, Spinoza still describes it in the language that pertains to the active individual. God, nature, or substance, though indistinguishable from reality itself, is still the 'cause' of all natural modifications.⁸⁸ Readers of the *Ethics* have not without reason been troubled by this transition from the 'substance' to its 'modes'.⁸⁹ The problem is whether Spinoza can avoid drawing a dividing line between the substantial 'actor' and the 'effects' produced.

This is not merely a philosopher's question. In fact, it is a universal conviction that, whenever a phenomenon occurs, there must be an identifiable 'something'—although we may not know what—which is to be held

⁸⁵ Spinoza, *Ethics* II, prop. 13, lemma VI.

⁸⁶ Spinoza, *Ethics* I, prop. 17, corollaries and scholium and prop. 29, scholium.

⁸⁷ Cf. M. Gueroult, *Spinoza*, Vol. I, 'Dieu', Paris 1968, 50: 'Par cette réduction de la substance à son attribut essentiel, Descartes et Spinoza expulsent d'elle la qualité occulte à laquelle sembleit condamner sa définition traditionnelle comme sujet d'inhérence, support inconnu de ses prédicats, seuls accessibles à l'entendement'.

⁸⁸ God is even called the 'efficient cause', the '*causa per se*' and the 'absolutely first cause' of all the modifications in nature. Cf. Spinoza, *Ethics* I, prop. 16 and corollaries.

⁸⁹ Cf. Woolhouse, *Descartes, Spinoza, Leibniz*, 192: 'Spinoza's account of God's causality, and of the relationship between substantial and creative *natura naturans* and modal and created *natura naturata* (...) is, to say the least, not easy to come to grips with'. A way out of the dilemma is to attribute to Spinoza the idea that the laws governing nature 'follow from God' in the sense that they are simply the laws that necessarily belong to a certain aspect of reality. However, this seems to obscure the fact that Spinoza considers 'substance' to be an immanent cause of things which, according to the very first proposition of the *Ethics*, is not to be identified with the things themselves. As Yirmiyahu Yovel argues: 'This implies that the laws of nature not only describe how particulars behave but *make* them behave in these ways'. Cf. Y. Yovel, 'The Infinite Mode and Natural Laws in Spinoza', *God and Nature. Spinoza's Metaphysics*, Leiden 1991, 93. Yovel adds that 'the type of causality [that the laws] exercise is logical rather than mechanical'—which only adds to the problematic character of substantial causality in Spinoza.

responsible for it. This is the conviction of both mythology and common sense and it is firmly anchored in the grammar of our language. Whenever we search for a substance, we search for a 'something' with properties and deeds. I have argued that the notion of substance was modelled on the experience we have of ourselves as human individuals. If so, the concept may illustrate in what way our most primitive experiences colour our view of the world that surrounds us. This is only to be expected. Our concepts are temporary tools for interpretation—shorthand descriptions of the metaphors we live by.⁹⁰ We see the world as a collection of individual 'things' and may not know of any other way. Seventeenth-century philosophy radically changed some of our ideas with respect to the notion of substance. Arnold Geulincx argued that in talking about substances we do not accept things 'as they are in themselves, but we give them the form of a subject'.⁹¹ Since the days of Geulincx and Descartes, the notion of 'subject' has itself undergone a remarkable change. Modern philosophers use the term as a synonym for the abstract 'I' of self-consciousness. A lot of philosophical effort has been spent on proving that this 'subject', or Cartesian *Ego*, is nowhere to be found. If it is true, as I have argued, that the notion of substance as it was used before Descartes was itself modelled on the experience of ourselves as individuals, a new perspective emerges. The impossibility of finding the 'self' with the philosophical tools that we have, is not due to the fact that there is no such thing. The problem is rather that the self has always been too close to consider and that, on second thoughts, there is nothing in nature quite like it.

⁹⁰ I borrow this expression from G. Lakoff and M. Johnson, *Metaphors We Live By*, Chicago 1980.

⁹¹ Geulincx, *Opera* II, 215.

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G. FEDERICI VESCOVINI

LES *VITE DI MATEMATICI ARABI* DE BERNARDINO BALDI
(Urbino 1553-1617)

Ireneo Affò, célèbre érudit italien du XVII^e siècle, écrit dans sa fameuse *Vita di Bernardino Baldi* que le grand amour que Baldi avait nourri pour le grec et le latin n'allait pas sans un grand intérêt pour les langues vulgaires et les langues orientales, comme les langues hébraïque, chaldaïque et arabe.¹

Il avait appris ces langues pendant les années d'études qu'il avait accomplies à l'Université de Padoue, c'est-à-dire pendant sa jeunesse. À l'étude de la langue arabe il aurait consacré plusieurs années, à Rome, sous la direction de Giambattista Raimondi qui, dit Affò, était 'in quell'idioma dottissimo'. Et Raimondi aurait publié à l'Antica Tipografia de nombreux ouvrages d'auteurs arabes, en langue arabe.² Comme Baldi lui même nous le rappelle dans un de ses *Distica*: 'felix Raimundi super sollertia fecit, ut quae donabit Biblia quaerat Arabs'.³ En outre Baldi avait déjà célébré l'enseignement de l'arabe du côté de Raimondi en chantant les vers:

Sovviemmi allor si come tu cortese
de gli arabici sensi il ver m'apristi
e come dolcemente anche seguisti
al mio desir che a varie lingue intese.

Néanmoins, selon Affò, Baldi dut perfectionner très tard, après 1596, son apprentissage de l'arabe. La connaissance de presque toutes les langues modernes et passées lui permit de rechercher et de choisir les documents d'«infiniti scrittori» dont il aurait pu rassembler les matériaux nécessaires pour écrire les vies de tous ceux qui 'più nelle matematiche si distinsero'. Ainsi il projette une série des Portraits, *Le Vite di matematici*, dont un des éléments les plus nouveaux aurait été constitué par les *Vie des mathématiciens arabes* du Moyen Âge.

¹ I. Affò, *Vita di Monsignor Bernardino Baldi primo abate di Guastalla*, Parma 1783, 10. Pour la vie de Baldi: G. Mazzucchelli, *Gli scrittori di Italia*, Brescia 1758, II, 116-125; F. Vecchietti, T. Moro, *Bibliotheca Picena*, Osimo 1791; I. Grassi, *Baldus redivivus*, Parmae 1717; G. Zaccagnini, *Bernardino Baldi nella vita e nelle opere*, Pistoia 1908²; R. Amatore, *Dizionario Biografico degli italiani*, s.v., V, 1963, 464 et ss.

² Affò, *Vita*, 20-25.

³ Baldi, *Distica*, in Affò, *Vita*, 21.

Les *Vite di matematici* furent editées par morceaux au milieu du XIX^e siècle: Enrico Narducci publia les *Vite di matematici italiani* dans le *Bulletin de bibliographie et d'histoire des sciences mathématiques et physiques du prince Baldassarre Boncompagni* en 1886; Demetrio Marzi publia en 1896 la vie de Paolo di Middelburg.⁴ En 1873, Moritz Steinschneider avait extrait du deuxième volume des manuscrits Albani des *Vite*, en particulier du volume consacré aux mathématiciens de la fin de l'Âge antique et du Moyen Âge (jusqu'au XV^e et au XVI^e siècle), les *Vie des mathématiciens arabes*, en tout quatorze, et il avait publié le texte dans le *Bulletin Boncompagni*.⁵ En outre, l'on peut trouver un index complet de toutes les *Vie* de Baldi dans l'étude précieuse d'Enrico Narducci, déjà mentionnée, qui avait été publiée dans le *Bulletin Boncompagni* en 1886.⁶

Les *Vies des mathématiciens arabes* représentent une partie très remarquable des *Vies* entières de Baldi, un document pour l'histoire des développement des mathématiques modernes, un petit peu différente des histoires courantes des mathématiques, auquel les savants arabes du Moyen Âge auraient apporté une contribution remarquable. Nous reviendrons plus loin sur ce sujet; nous voulons pour le moment rappeler l'étrange histoire des manuscrits de Baldi qui avaient été possédés par Boncompagni, qui avaient été étudiés par Narducci et par Steinschneider, qui disparurent à la fin du XIX^e siècle, et qui furent retrouvés par Stanislaw Bilinsky en l'année 1974-75, à l'occasion des célébrations de Copernic. Bilinsky publia la *Vie de Copernic* des manuscrits retrouvés.⁷ A partir de ce moment, les

⁴ D. Marzi, *La questione della Riforma del Calendario del Quinto Concilio Lateranense (1512-1517)*, Firenze 1896.

⁵ M. Steinschneider, 'Vite di matematici arabi di Bernardino Baldi', *Bullettino di bibliografia e storia delle scienze matematiche e fisiche*, V, nov. dic. 1873. À propos de la famille Albani qui possédait les manuscrits de Baldi cf. B. M. Peebles, 'The Bibliotheca Albana Urbinitis', *Didascalicae, Studies in honour of Anselmo M. Albareda*, ed. S. Prete, New York 1961, 327-352.

⁶ E. Narducci, 'Vite di matematici italiani scritte da Bernardino Baldi', *Bullettino di bibliografia e di storia delle scienze matematiche e fisiche* 19 (1886), 355. Cf. aussi B. Boncompagni, 'Intorno alle Vite inedite di tre matematici (Giovanni Daneck di Sassonia, Giovanni de Lineriis, e fra Luca Pacioli da Borgo Sansepolcro) scritte da Bernardino Baldi' in *Bullettino di bibliografia e di storia delle scienze matematiche e fisiche* 12 (1879), 352-438, 863-872. Cf. aussi G. Uzielli, 'Ricerche intorno a Paolo dal Pozzo Toscanelli, della biografia di Paolo dal Pozzo Toscanelli scritto inedito di Bartolomeo (sic) Baldi', *Bollettino della Società geografica italiana* 9 (serie II) (1884), 129-133.

⁷ B. Bilinsky, *La vita di Copernico di Bernardino Baldi dell'anno 1588*, Conferenze (fasc. 61), Biblioteca e Centro di Studi a Roma dell'Accademia Polacca delle scienze, Roma, 1973, 109; du même *Vite dei matematici di Bernardino Baldi*, Roma, Accademia dei Lincei (Rendiconti (...) serie 8, vol. 61, 5 nov. 1975), 305 et ss.; du même *Prolegomena alle Vite dei matematici* (Conferenze, 13 feb. 1973, 30 ott. 1975), Roma, Biblioteca e Centro Studi a Roma dell'Accademia Polacca delle Scienze, 1973, 1975. Au sujet de ces manuscrits cf. aussi P. L. Rose, *Rediscovered Manuscripts of the Vite di Matematici and Mathematical Works by*

manuscrits de Baldi possédés par Albani-Boncompagni disparurent de nouveau, jusqu'au moment où j'eus la chance de les retrouver et de pouvoir les étudier en photocopie.

Les premiers possesseurs des manuscrits originaux de Baldi avaient relié les papiers en trois volumes, suivis d'un volume d'index qui avait été décrit par Narducci. Le deuxième volume contient nos *Vies des mathématiciens arabes*, qui sont mêlés à un grand nombre de personnages très différents du Moyen Âge et de la Renaissance, philosophes, érudits et théologiens (comme Avicenne et Thomas d'Aquin) ou de la fin de l'Antiquité (Quintiliano, Antemio Tralliano, Apollodoro, Deodoro Alessandrino, Sosigene il più giovane, etc.). Baldi nous explique ce curieux mélange d'auteurs, qui devait être probablement enraciné dans une quelconque tradition scientifique de son temps (que nous devons déceler un peu mieux) pour laquelle les Mathématiques étaient conçues selon un lien positif très étroit avec la philosophie et l'astronomie, conçue aussi comme astrologie: c'était le modèle d'une encyclopédie bien déterminée des sciences mathématiques, qui avait été inspiré des sciences arabes du Moyen Âge selon la conception de la supériorité des sciences qui viennent de l'Égypte,⁸ et qui avaient été révélées par les premiers prophètes, Abraham comme Moïse, Noé, etc.: une encyclopédie qui arrive jusqu'au Baldi à la fin du XVI^e siècle. En d'autres termes, Baldi, même s'il avait été célébré comme grand humaniste, helléniste et latiniste, ne paraît pas être le représentant d'un savoir classique et 'puriste' qui refuse les barbaries scientifiques arabolatines du Moyen Âge, bien qu'il soit choqué par les noms 'barbares' de ces mathématiciens arabes.⁹

Baldi a conscience que cette conception peut irriter ses lecteurs, et pour cette raison il justifie l'insertion des philosophes parmi les mathématiciens au sens étroit, en écrivant dans sa Préface que les plus grands philosophes professionnels, comme Thalès, Anaxagore, Platon, Démocrite et beaucoup d'autres, n'avaient pas été seulement des philosophes mais aussi 'geometri, astrologi et insomma eccellenti ne le matematiche ancora (...) Quanto poi s'aspetta al titolo dell'opera io la chiamo Vita de' matematici e non de' geometri o astrologi, per abbracciarvi tutto il genere sotto il quale si raccol-

Bernardino Baldi (1556-1617), Roma, Accademia Nazionale dei Lincei Rendiconti, classe di scienze fisiche, matematiche e naturali, vol. 56, 1974, 272 et ss.

⁸ 'Scrissi dunque, raccogliendo e ordinando le cose, ch'io presi da un infinito numero de libri, le Vite de' matematici più nobili, per essere questi il primo che prendendo la filosofia e le matematiche da gli Egittii, l'apportasse à Greci, onde l'abbiamo noi' (Prefazione del Baldi, in E. Narducci, 'Vite di matematici italiani', 1-3).

⁹ '(...) Sono dunque tante e tali le matematiche e non si scriverà di coloro che in quelle sono stati eccellenti, e a professori di sì degne scienze si proporranno i grammatici, i sofisti, i pittori et altri di più ignobili professioni? Non mi pento io dunque d'aver impiegata la mia poetica à soggetto sì degno' (ibid.).

gono gli aritmetici, i musici, i meccanici, i prospettivi e gli altri che attendono a quelle professioni che alle matematiche sono subalterne'.

Cette oeuvre de Baldi soulève beaucoup de difficultés sur les sources qu'il a utilisées. Ainsi l'édition partielle du Steinschneider a suscité beaucoup de questions, si bien qu'elle ait été vraiment fondamentale et riche de précieux renseignements.

Le pauvre Baldi est très conscient des limites de sa recherche et il se plaint, dans son introduction, des difficultés qu'il avait rencontrées pour retrouver et rassembler les documents nécessaires à son ouvrage: travail qu'il n'avait pu faire dans des grandes villes, mais dans un petit centre comme Guastalla.¹⁰ Il est évident que les sources principales de Baldi sont très indirectes, que les textes qu'il connaît le mieux sont ceux des grands astronomes et astrologues arabes, comme Albumasar, Zahel Aliabenragel, Alkindi, dont les ouvrages avaient été imprimés à la fin du XV^e siècle et au commencement du XVI^e; il puise même dans les ouvrages de savants plus ou moins contemporains comme Julius Cesar Scaliger et surtout Jerolamus Cardano, Luca Gaurico, Pierre de la Ramée, Francesco Giuntini, Francesco Barozzi, Jean Stäffler. Pour les savants grecs, une de ses sources principales a été les *Vies de Diogène Laërce*. Et une des sources fondamentales pour l'idée toute humaniste d'une rédaction de biographies a certainement été le *De inventoribus rerum*, de l'historien d'Urbino Polydore Virgile (Venezia 1499; Bâle 1540).

Mais s'il a eu la réputation de bien connaître la langue arabe, on a bien l'impression, en lisant ces Portraits des mathématiciens arabes, qu'il ignorait comme presque tout le monde, les textes originaux, pas seulement en arabe, mais aussi en latin et que, en conclusion, il se référait à une tradition de connaissances historiques de son temps, très médiatisée. C'est pour cela que dans le cas de la vie de Geber-ibn Aflat, il le confond avec Geber l'alchimiste: une équivoque historique qui durera longtemps. Et en ce qui concerne Messahalla il le confond avec Maslama al-Magriti.

Néanmoins l'amour pour la langue arabe est attesté par Ireneo Affò qui nous raconte que Bernardino avait l'habitude pendant son repas de lire le *De civitate dei* d'Augustin en latin et, après le repas, Euclide en arabe: 'In studios sic assiduus fuit, ut saepe et legeret et comederet Sancti Augustini libros de civitate dei inter prandium evolvit (...), a prandio Euclide arabice editum'.

¹⁰ 'Due cose mi sono state contrarie: l'oscurità de l'historia e la penuria de' libri; havendomi bisognato di scrivere non in Roma, in Bologna o in Padova, ma in Guastalla, piccola terra de la mia residenza. A le quali difficoltà potrei aggiungere la terza del non haver havuto in ciò Principe alcuno favorevole, col mezo del quale io potessi essere informato de le historie de' Matematici, che hanno fiorito in Francia, in Germania e in altri luoghi lontani' (Da E. Narducci, 'Vite di matematici italiani', 355).

Après sa mort, qui était survenue en Urbino en 1617, il fut célébré pour ses études sur les mathématiciens grecs: sa traduction *De li automati, overo Machine semoventi di Herone Alesandrino*, fut publiée quand il était encore en vie; la *Cronica de' matematici* (qui est autre chose que les *Vies*) ou *Epitome delle Vite loro*, fut éditée à Urbino en l'année 1707. En 1621, à Mainz, furent publiés les *Exercitationes in Mechanica Aristotelis problemata* et, entre 1612-1616 à Augsbourg, la traduction de deux traités de Vitruve et un texte d'Héron. Ainsi les *Vite de matematici arabi* doivent être considérées d'un point de vue methodologique qui n'est pas celui de l'histoire des sciences contemporaines; mais elles doivent être étudiées du point de vue du temps de Baldi. En premier, il reflète bien le goût tout humaniste pour les biographies: l'histoire des mathématiques se réalise par portraits, comme l'histoire des arts par les *Vies des Artistes* dont la renommée des *Vies des artistes* de Vasari.

Les XV^e et XVI^e siècles ont vu une extraordinaire prolifération de biographie: de *Vite* di Vespasiano da Bisticci au *Vitae* des princes de Milan et beaucoup d'autres: un genre littéraire très à la mode au cours de la Renaissance italienne. Mais cette idée de histoire biographique pose des questions à la rédaction de Baldi parce qu'il avoue ne pas posséder des documents suffisants pour écrire ses biographies, surtout des auteurs arabes du Moyen Âge, et pour cela il devra écrire ses biographies en puisant à leurs oeuvres qui sont connues. Cela peut expliquer la faible connaissance des siècles où vécurent les savants arabes dont il traite, et l'étrange généalogie de leurs activités. Les connaissances qu'il pouvait avoir des écrivains arabes étaient très indirectes, tirées par exemple de la mystérieuse *Tavoletta Historica* d'Erasmus Reinhold, qu'il cite dans sa *Cronica*¹¹ et dans la *Vie d'Albumasar*, qui néanmoins fournissait des renseignements très pauvres. Pour cela il écrit dans une de plus remarquables *Vies*, celle d'Albattani,¹² que 'obscurissime sono a noi l'histoire de gli Arabi, per essere stati pochi, che ne la lingua latina o ne l'italiana habbiano tradotti i libri loro historici; onde nasce che difficilissima cosa e quasi impossibile sia lo scrivere historie dipendenti da la loro cognizione. Nondimeno ancorché ciò sia il vero, dobbiamo tentare di apportare a' Matematici di quella nazione quel poco di lume che si trova a guisa di scintille, sparso per i libri loro che s'hanno per le mani, et anco per l'histoire nostre'.

¹¹ *Cronica*, Urbino, 1707, 125. Cf. aussi P. L. Rose, *The Italian Renaissance of Mathematics. Studies on Humanists and Mathematicians from Petrarch to Galileo*, Genève 1975, 252, 278. Rose qui suit Steinschneider, affirme que Baldi cite la 'Tavoletta de Reinhold' des Notes de la *Theoricae Novae planetarum Georgii Purbachii*, Wittenberg 1542, f. 199v. La 'Vie' de Erasmo Reinold de Baldi se trouve au MS Artom-Celli 63, ff. 333-341.

¹² MS Artom-Celli, 63, f. 35r-38r (ex Boncompagni 154, ex Albani 618): addi 14 ottobre 1588.

Comme on peut le vérifier en lisant cette biographie, les sources de Baldi viennent du Moyen Âge et des compilations des astrologues et des astronomes de son temps, comme des connaissances qui ressortent de la célèbre Bibliothèque de Simon Phares,¹³ de l'oeuvre de Francesco Giuntino, de Luca Gaurico, du livre *De subtilitate* de Cardano et d'autres chroniques du Moyen Âge. Ainsi dans le cas de la *Vie de Albattani* Baldi puise en donnant les premiers renseignements, très généraux, d'Albattani, du *Chronicum* de fra' Filippo Foresti da Bergamo.¹⁴

Et de cette source naquit la confusion avec Serapion, pour laquelle Baldi écrit que 'attese Albategni a due professioni con molto profitto, cioè a la Medicina e l'astrologia; ch'egli fosse medico et eccellente, viene affermato da fra Filippo nel Supplemento, ancorché da lui sia stroppiato il nome e distorto in Albaterio'. Donc Foresti aurait attribué à Albattani la traduction de Galien selon la témoignage de Serapion, dont on croyait qu'il avait vécu vers 1070 et, ainsi, le même Albattani: 'Albaterius natione Arabs medicus clarissimus tempestate hac floruit: qui libros Galieni in linguam Arabam convertit, Serapione teste'.¹⁵

Malgré cette confusion qui dérivait de telle sources incertaines et fabuleuses, le grand mérite dans la *Vie d'Albattani* de Baldi est d'avoir souligné l'importance d'Albattani pour la connaissance de l'Almageste de Ptolémée parmi les latins et pour les améliorations qu'il y aurait apportées: 'Fu studiosissimo del opere di Tolomeo e come scrive Rodolfo Brugesel¹⁶ nel prohemio del Planisferio, restrinse in Epitome l'Almagesto; osservò da settecento quaranta anni in circa dopo Tolomeo onde scoperse molte cose in quell'autore che havevano bisogno di emendatione' (MS Artom-Celli 63, f. 36r). Mais surtout Baldi souligne que Paul de Middelburgo et Jean Stoflero, ayant ignoré cette oeuvre d'Albattani, en avaient eu une très grande pert, lorsqu'ils essayèrent de réformer le calendrier. Par contre, l'Epitome d'Albattani aurait été utilisée par Jean de Monteregio avec profit tandis que, au Moyen Âge, elle aurait inspiré le *Computus maior* de Campanus¹⁷ et, dans son temps, les

¹³ Cf. aujourd'hui J. P. Boudet, *Lire dans le ciel. La Bibliothèque de Simon de Phares, astrologue du XVe siècle*, Bruxelles 1994.

¹⁴ Fra' Filippo Foresti Da Bergamo, *Chronicon*, Varese 1488 per Bernardinum de Benalis.

¹⁵ *Supplementum Chronicorum Foresti*, Venise 1483, 245.

¹⁶ Il s'agit de l'auteur de la dedicace de l'édition de la traduction *De scientia astrorum* d'Albattani de Platon de Tivoli, Bononiae 1586. [See Lorch's contribution to this volume—Eds.]

¹⁷ MS Artom-Celli 63, ff. 36r. L'oeuvre de Campanus a été publiée dans le recueil *Sphaera cum Commento*, Venise 1513, ff. 150r; cf. B. Boncompagni, *Della vita e delle opere di Gherardo Cremonese*, Roma 1851, 93; Campanus de Novara, *Theorica planetarium*, ed. F. S. Benjamin et G. Toomer, Madison 1971; cf. aussi mon étude 'Michel Scot et la Theorica planetarium Gerardi', *Early Science and Medicine* I (1966), 272-282.

valeurs de la précession des équinoxes d'Albattani auraient été longuement discutées par Girolamo Fracastoro dans sa *Homocentrica*¹⁸ 'Onde frequente mentione s'ha di lui appresso Girolamo Fracastoro ne la sua Homocentrica'.¹⁹

Les connaissances erronées que Baldi nous a transmises des savants arabes n'ôtent rien à la grande valeur de cette histoire des mathématiques qui sont une série de biographies de mathématiciens qui devrait envelopper tous les savants du monde, sans bornes ni limites. Baldi se présente comme un esprit libre, sans préjugé envers les arabes, les hébreux, ou les savants plus éloignés de l'Occident chrétien. Il veut écrire une véritable *Histoire universelle* selon le modèle de la *Bibliotheca universalis* de Conradus Gesner,²⁰ auquel il se réfère constamment (par exemple pour l'attribution de l'oeuvre *De radiis stellicis* à Alkindi²¹) ainsi qu'à plusieurs autres biographies. Sauf les cas où il puise directement aux oeuvres qui avaient été imprimées, les connaissances historiques que Baldi a des philosophes et des mathématiciens arabes et latins du Moyen Âge reflètent de façon exemplaire la situation historique de la Renaissance, qui doit se confronter aux oeuvres et aux activités des savants des siècles antérieurs, de la fin de l'Antiquité et du Moyen Âge, qui n'avaient presque jamais été imprimés et qui doivent circuler avec grande difficulté dans les Bibliothèques manuscrites du Moyen Âge et de la Renaissance.

Mais les *Vies des mathématiciens* de Baldi sont remarquables non seulement par sa liberté d'esprit envers tous les savants du Moyen Âge, latins, arabes et hébreux, mais surtout par une conception des encyclopédies des sciences mathématiques qui était évidemment de son temps, et qui ne correspond pas à une certaine conception historiographique moderne, abstraite, des sciences mathématiques. En d'autres termes, l'esquisse qu'il dessine de l'origine et de la généalogie des mathématiciens n'est pas celle de l'historiographie scientifique et philosophique du XIXe et, en partie, du XXe siècle, selon laquelle les mathématiques sont nées exclusivement avec le rationalisme de la pensée grecque et du XVIIe siècle.

Par contre Baldi retient l'idée d'une autre tradition, celle du Moyen Âge qui est, par certains aspects, chrétienne ou biblique, telle qu'elle a été attestée dans l'oeuvre de Pierre de Padoue sur l'origine des sciences mathématiques dont l'astronomie-astrologie est la science principale et première, et qui vient des patriarches et de l'Egypte. Rose dans le chapitre

¹⁸ Gerolamo Fracastoro, *Homocentrica*, Venetiis 1588, f. 20r.

¹⁹ Baldi, *Vie d'Albattani*, MS Artom-Celli 63, f. 37v.

²⁰ *Bibliotheca universalis sive Catalogus omnium scriptorum completissimus autore Corrado Gesnero*, Zurich 1545.

²¹ Gesner, *Bibliotheca*, 352r: 'Alkindi, eiusdem opinor licet praenomen non addatur, de radiis stellicis, opus in magis extat'.

'The Urbino School III: Bernardino Baldi, Renaissance Historian of Mathematics' rappelle que la doctrine de l'origine égyptienne des mathématiques de Baldi est soulignée par Baldi lui-même en la référant à Eudème de Rhodes.²² L'origine égyptienne des mathématiques, qui avait été résumée par Eudème, se trouve aussi dans l'introduction au commentaire d'Euclide de Proclus²³ du quel Baldi écrit une vie aussi très remarquable.²⁴

Proclus et Diogène ont été les sources principales de Baldi; mais il suit aussi la tradition biblique selon laquelle les mathématiques en général avaient été inspirées par Abraham et par les grands prophètes, et de cette façon tous les grands inventeurs des sciences, les Égyptiens, les Grecs, les Hébreux, les Arabes appartiennent tous à la même révélation universelle qui vient de Dieu.

C'est la doctrine des origines des sciences qui avait été développée par Polydore Virgile dans son *De rerum inventoribus libri octo* (Bâle 1540, pp. 54-59), qui néanmoins plonge ses racines dans une tradition scientifique syncrétiste antérieure qui remonte aussi au Moyen Âge. Elle est attestée comme bien répandue et acceptée, et on en a le témoignage dans les oeuvres de Roger Bacon et de Pierre d'Abano: l'astronomie, qui est une science mathématique, ainsi que les sciences libérales avaient été fondées par les prophètes. Baldi accepte donc une tradition des origines des mathématiques qui est à la fois biblique et qui vient de la Chaldée, d'Égypte, de Babilonie et qui remonte à la tradition des sciences arabes du Moyen Âge.²⁵

Dans son tableau des vies des mathématiciens arabes, il faut souligner en outre que Baldi ne prête aucune attention aux développements de l'algèbre arabe et pour cette raison on n'y trouvera pas la vie d'Alkhuwarizmi. Par contre il dessine un portrait d'Alhazen qui est un de plus beaux de ses Vies, où il souligne l'originalité de la perspective d'Alhazen. Pour cette vie il a puisé très largement à l'édition de Bâle de Frédéric Risner et de Pierre de la Ramée:

Nulla, come dice il Risnerio, mostra d'aver preso, né da Euclide, né da Tolomeo, eccetto forse alcune cose, da Archimede, da Apollonio, da Avenello e da Damiano i quali si sa che hanno scritto alcune opere di Prospettiva (...)

²² *The Italian Renaissance of Mathematics*, Genève 1975, 260 et ss.

²³ Cf. Proclus, *A Commentary on the First Book of Euclid's Elements*, transl. G. R. Morrow, Princeton 1970, 52-56.

²⁴ Cf. MS Artom-Celli 63, ff. 476r-496r datée 4 nov. 1590.

²⁵ Pour la thèse de Baldi cf. la citation à la note 8. Pierre d'Abano aussi avait écrit: 'Dicitur autem quod eos primitus docuit Sem, filius Noè, unde in Sadan: dixit Albumasar quod Caldei primo adinvenerunt astronomiam, deinde Indi, postea Iudei, postea Egyptii, deinceps Perse, demum Romani sive Graeci, deinde Syri, posmodum Saraceni. Ipsius etiam auctores pronuntiantur fuisse gerarchiarum summos, Noè ut tactum, cum suis Abraham Moysem et Job cum aliis non paucis' (Pierre d'Abano, *Lucidator dubitabilium astronomiae*, ed. G. Federici Vescovini, Padova 1992², 146-147).

Quando Alhazeno fiorisse non si sa di certo: ancorché egli debba riporsi nel numero de più eccellenti antichi che gli Arabi s'abbiano avuti. Il Risnerio, seguendo le conietture, tiene potersi credere ch'egli fiorisse intorno mille e cento anni dopo la natività di Cristo, nel qual tempo fra barbari e saraceni fiorivano gli studi di tutte le arti buone e particolarmente quelli de le Mathematiche. Alhazeno come scrive il Risnerio, suona ne la lingua arabica 'omo da bene'. Del opera di costui è da credere che si servisse molto Vitellione in quei libri ch'egli scrisse de la medesima materia.²⁶

Si les connaissances factuelles que Baldi manifeste dans ses Biographies ne paraissent pas très développées aux yeux de l'historiographie moderne, nourrie de philologie, et s'il nous transmet les erreurs de la tradition à laquelle il puisait et ainsi l'incertitude des lieux de naissance et des siècles où les savants arabes avaient vécu, néanmoins cela n'ôte aucune importance à l'extraordinaire valeur de document de cette oeuvre de Baldi, d'autant qu'à la fin du XX^e siècle, malgré les progrès des études de Paul Kunitsch, Fuat Sezgin, Manfred Ulmann, Charles Burnett, David Pingree, B. R. Goldstein, A. I. Sabra, R. Rashed, Morélon et tant d'autres, nous ne possédons pas encore les données suffisantes pour la reconstruction d'une histoire complète des mathématiques des siècles passées et surtout du Moyen Âge arabo-latin.

Ce qui est certain, c'est que ces biographies maintiennent un intérêt envers une encyclopédie scientifique qui remonte au Moyen Âge, de la part d'un humaniste qui n'avait pas de préjugé envers les siècles dits obscurs du Moyen Âge arabo-latin, selon l'idée syncrétiste d'une histoire universelle des sciences mathématiques.

²⁶ MS Artom-Celli 63, f. 59v-60r. Cf. ici Appendice.

APPENDICE

Gebro

(Vie de Jeber ibn Aflah, dit Geber par les latins, MS Artom-Celli 63, ff. 68r-69r, *Cronica*, 74-75).

Fu Gebro di nazione spagnuolo. Come affermano tutti, nacque in Siviglia, che fu detta Hispali, onde Francesco Tarrafa²⁷ Barcellonese, parlando di questa città, fa commemoratione di Gebro. Attese egli a le cose de la filosofia e, con grandissimo profitto, diede opera anco a le Matematiche, ne le quali, e particolarmente nel astrologia, egli divenne famoso di maniera che fra gli scrittori guadagnossi titolo di acutissimo. E Girolamo Cardano,²⁸ nel suo libro *De subtilitate*, dopo aver celebrato Alchindo, passa alle lodi di Gebro con queste parole:

Gebro Spagnuolo, con bellissima inventione, avendo Tolomeo da cinque quantità con gran fatica ritrovata la sesta, questi ne le medesime con le tre, la quarta. Molte cose, anco di quelle che appartengono a lo stato del cielo, mutò in meglio, di maniera che altri può accorgersi molto meno esser dannosi a gli ingegni i grandissimi caldi che i freddi gelati.

Così Girolamo, la cui lode sarebbe maggiore, se non fosse assai leggiera appresso i migliori litterati l'autorità di lui. Scrisse molte opre Gebro²⁹, fra le quali appresso principalissima è quella che s'intitola *Sintaxi astronomica*³⁰, ovvero opera dimostrativa, ne la quale in nove libri raccolse quanto aveva trattato ne la gran construttione Tolomeo, ne la cui opera spesse volte egli si sforza di gittar a terra le cose di Tolomeo; il che vien accennato dal Cardano, il quale pare che tacitamente aderisca in Gebro; ma con molta

²⁷ À propos de Geber ibn Aflah mort environ 1145, cf. R. P. Lorch, 'The Astronomy of Jabir ibn Aflah', en *Centaurus*, 19 (1975), 92-120; 20 (1976-1977), 15-33; F. Sezgin, *Geschichte des arabischen Schrifttums*, VI, 1976, 52, 93; P. D'Abano, *Lucidator dubitabilium astronomiae*, ed. G. Federici Vescovini, Padova 1992², 91-97, 301-305; G. Saliba, *A History of Arabic Astronomy, Planetary Theories during the Golden Ages*, New York 1994, 24-25, 29, 63, 75, 114, 118, 252, 258, 280. C'est evident que Baldi n'avait pas ces connaissances. Ici il renvoie à une compilation de Francisci Taraphae Barcinonen, *De origine ac rebus gestis Regum Hispaniae liber*, Antverpiae, in aedibus Ioannis Steelsij, 1563.

²⁸ Girolamo Cardano, *De subtilitate*, Parigi 1550, 315; de Cardano cf. A. Ingegno, *Saggio sulla filosofia di Cardano*, Firenze 1980; *Girolamo Cardano, Philosoph, Naturforscher, Arzt*, hrsg. E. Kessler, Wiesbaden 1994.

²⁹ Sezgin, *Geschichte* pour les indications des MSS en arabe et traduction latine.

³⁰ *De astronomia libri X* (transl. Gerardi) Norimberga, 1541 (?), Giovanni Petreio.

diligenza fu poi diffuso Tolomeo da Alessandro Piccolomini³¹ in un libro destinato a questo, di cui egli fa mentione nel proemio de la sua *Parafrasi* sopra le *Mecaniche*. In questo libro, oltra le cose de' moti, trattò Gebro de le ragioni de gli anni e de le feste, secondo gli Israeliti, i Giacobiti, i Nestoriani, i Siri e i Persi. Fu oltra di ciò grandissimo alchimista³², e ne scrisse volumi che s'hanno per le mani da gli affamati di quella proffessione. Fra gli altri scrissene uno, diviso in tre libri, ch'egli intitolò il libro del perfetto magistero; un altro dela somma de la perfettione de' Metalli, overo del perfetto magistero de' Metalli;³³ un altro del far le fornaci Alchimiche, sopra il quale scrisse commentarii Giovanni Braccresco. Compose anco in altro genere, cioè del investigatione de la uerità, un libro de la Fortuna, uno de la Pietà o Misericordia et uno del Regno.

A di 27 Novembre 1595.

³¹ D'Alessandro Piccolomini (1508-1578) cf. M. Delambre, *Histoire de l'astronomie du moyen âge*, Parigi 1819, 445. Au sujet du Piccolomini Baldi même a nous laissé une *Vie* (MS Artom-Celli 63, 403-416).

³² Ici Baldi confond l'un avec l'autre Geber, l'alchimiste, selon une tradition assez commune. De Geber l'alchimiste (Geber ibn Hayyan qui a veçu au VIII siècle) cf. P. Kraus, *Jabir ibn Hayyan, Contribution à l'histoire des idées scientifiques dans l'Islam*, Paris 1986; F. Carmody, *Arabic Astronomical and Astrological Sciences in Latin Translation*, Berkeley 1956, 163-165

³³ Pour ces oeuvres de l'alchimiste cf. P. Kraus, *Jabir ibn Hayyan*, 14 et ss.

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